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Astronomy®

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January 2003

UNDER ALIEN SKIES

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The Meade 30th anniversary sale

Buy a Meade LX90 or LX200GPS Schmidt-Cassegrain at the lowest prices ever offered!

Founded in 1972 as a one-person kitchen table mail-order operation, Meade Instruments has grown to become a $100 million enterprise with 500 employees and with distributors in 36 countries. This record of growth has been made possible by the astronomical community — amateur and professional astronomers and educators — who have made Meade the largest-selling telescopes in the world. Now, in celebration of our 30th year, Meade LX90 and LX200GPS telescopes are available for a limited time at their lowest prices ever.

8" LX90	*reg.* $1695; *now*	**$1495;**	*save* **$200**
8" LX200GPS	*reg.* $2495; *now*	**$1995;**	*save* **$500**
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12" LX200GPS	*reg.* $3495; *now*	**$2995;**	*save* **$500**
7" LX200GPS	*reg.* $2995; *now*	**$2495;**	*save* **$500**

Ultra-High Transmission Coatings (UHTC) group: *(see facing page)* 8" LX90 or 8" LX200GPS – $175; 10" LX200GPS – $235; 12" LX200GPS – $295; 14" LX200GPS – $350; 7" LX200GPS Maksutov-Cassegrain – $150.

Packing & shipping charges in the 48 states: 8" LX90 – $95; 8" LX200GPS – $105; 10" – $145; 12" – $215; 14" – $265; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices. Certain Meade telescopes and Autostar control systems are manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide. Special LX90 and LX200GPS prices are valid for purchases from authorized Meade dealers in the U.S.A. **between September 15 - December 31, 2002.**

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14" LX200GPS
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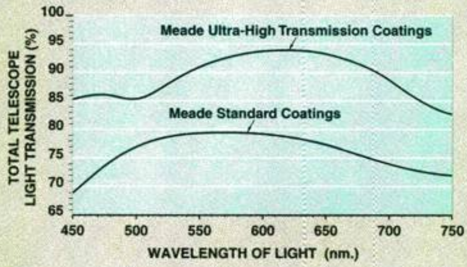
Buy a $650 Super Plössl eyepiece set for your LX90 or LX200GPS for only $99!

Through December 31, 2002, you can buy a full set of Meade premium-grade Series 4000 Super Plössl eyepieces, packed in a Meade #771 aluminum carrying case, for only **$99** with the purchase of a Meade LX90 or LX200GPS telescope.

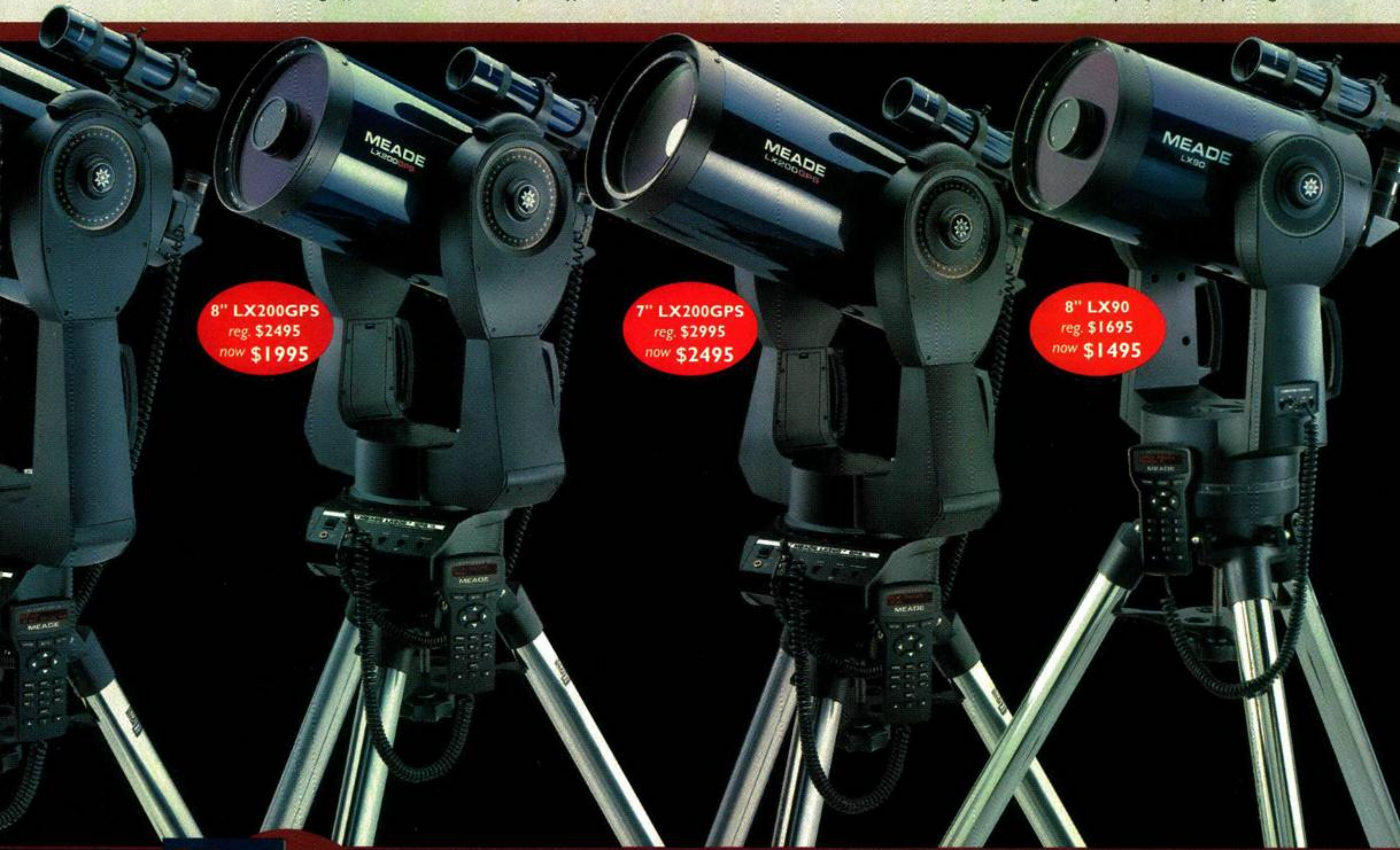
See the full-page Meade ad in this issue for complete terms and conditions on this amazing offer.

Meade Ultra-High Transmission Coatings (UHTC) Group: The optical coatings provided as standard equipment with Meade Schmidt-Cassegrains equal or exceed the reflectivity/transmission of virtually any coatings currently offered in the commercial telescope industry. Alternatively, however, the UHTC group is available optionally at the time of telescope purchase on Meade LX90 and LX200GPS models and includes an exotic series of multi-layer coatings on the telescope mirrors and on the correcting lens. The UHTC group dramatically increases image brightness by about 20% across the visible spectrum. *Image brightness of the Meade 10" LX200GPS, for example, is effectively increased by about one full inch of aperture.*



SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; operating instructions.

SPECIFICATIONS: 7", 8", 10", 12", and 14" LX200GPS — Each complete telescope includes 8", 10", 12" or 14" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); primary mirror lock; 4-speed zero image-shift microfocuser; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and 7-port multi-function control panel, including two RS-232 serial interface ports; manual and electric slow-motion controls on both axes; Autostar II control system with 3.5-Megabyte flash memory, digital readout display, permanently programmable Smart Drive and 185-speed drive controls on both axes, High-Precision Pointing, and GO TO controller; 145,000-object onboard celestial software library; GPS alignment system with 16-channel GPS receiver, magnetic declination compensation, and true-level and North electronic sensors; 12vDC telescope power supplied from internal battery compartments accepting 8 (user-supplied) C-cells (optional 25 ft. cords available for powering from auto cigarette lighter plug or from 115vAC); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12", 14"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12", 14"); operating instructions.



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Astronomy®

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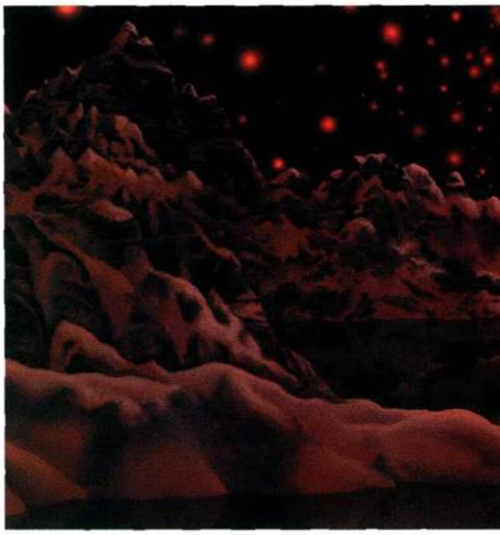

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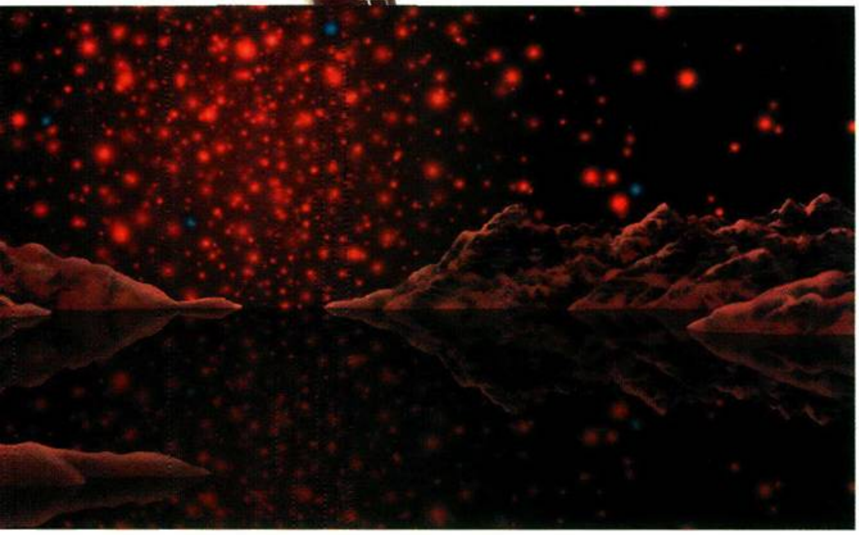

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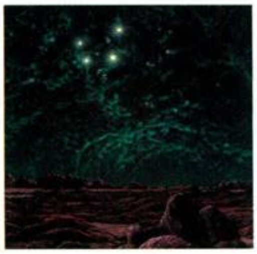
BEHIND THE SCENES

BY DAVID J. EICHER

Seeing Other Worlds

On a warm, muggy night, surrounded by the whir of clock drives and the rustle of star charts, I spent hours trudging back and forth between the upper and lower telescope fields. It was the Texas Star Party, a mecca for amateur astronomers in West Texas where the skies are superbly dark and the expertise high, all in the shadow of McDonald Observatory. This particular year, it was pretty much business as usual. A cascade of 20-inch scopes stood like stumps aimed heavenward; a few 30-inch+ monsters loomed in the darkness, hiding their matching ladders.

The objects people were looking at ranged from the usual Lagoon and Trifid nebulae, to the garden variety NGC objects, to the exotic — things like quasars in galaxy fields. More than once that night, I heard people ask what the universe would look like from those distant worlds. Relativity really gets a mental workout when you apply it to how the cosmos might appear from planetary perches near myriad favorite deep-sky objects. What would the sky look like from inside a globular star cluster? From the edge of a giant molecular cloud like the Orion Nebula? From the cusp of a very different kind of star — a red dwarf?



The Orion Nebula up close and personal. Lynette Cook

Sonoma State University astronomer Phil Plait tackles this question in his article "Under Alien Skies" (page 37). He has extensively researched the environments of a variety of our favorite deep-sky objects and, with the talent of astronomical artist Lynette Cook, reveals what these gems would look like close-up. It's a scene that we will never experience for real — Lynette's paintings will take us as close as we can get to knowing how other living creatures might experience the sky in such busy regions of the galaxy.

Amateur astronomers are not just getting closer to discoveries in their imaginations, however. Astronomer Greg Laughlin of the University of California–Santa Cruz fires a blockbuster salvo in his story "Transitsearch.org" (page 54). Laughlin shows that with the right equipment, amateur astronomers can discover an extrasolar planet from their backyards. Talk about potential headlines!

* * *

With this issue, *Astronomy* enters its 30th year of publication. I am excited to tell you that you are about to see a new *Astronomy*. We have spent months carefully talking with readers and finding out what you would like to see more of. Look for exciting changes in the March 2003 issue. You'll find more hobby articles, stellar science coverage, and many improvements and additions that will make *Astronomy* better than ever before. Stay tuned.

Yours truly,

Dave Eicher
Editor

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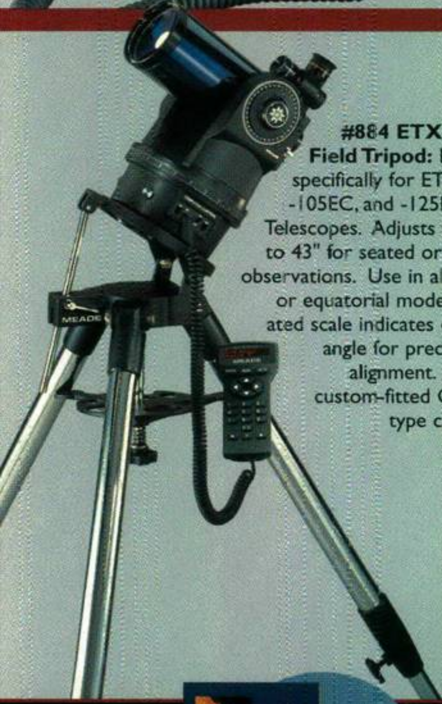
ETX-90EC
$495
ETX-70AT
$299
ETX-125EC
$895
ETX-105EC
$695

ETX-90EC, -105EC, and -125EC shown with optional #497 Autostar Controller



#884 ETX Deluxe Field Tripod: Designed specifically for ETX-90EC, -105EC, and -125EC Astro Telescopes. Adjusts from 25" to 43" for seated or standing observations. Use in altazimuth or equatorial modes; graduated scale indicates elevation angle for precise polar alignment. Includes custom-fitted Cordura-type carry bag. **$199.95**

Meade ETX telescopes are the largest-selling modern telescopes in the world, with hundreds of thousands of ETX's now in the field. And every one with the unique ETX trademarks: matchless diffraction-limited optical performance; ultra-portable, contemporary design; and revolutionary Autostar GO TO capability. *See the Meade General Catalog for full details.*

MEADE ETX ASTRO TELESCOPES

Complete per catalog specifications:

ETX-70AT with #494 Autostar and #882 Field Tripod	$299
ETX-90EC with Electronic Controller	495
ETX-105EC with Electronic Controller	695
ETX-125EC with Electronic Controller	895
#497 Autostar controller for ETX-90EC, ETX-105EC, or ETX-125EC	149

Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%: ETX-90EC– $50; ETX-105EC– $75; ETX-125EC– $95

Prices shown are suggested U.S. mail-order retail prices.

Buy a $650 Super Plössl eyepiece set for your ETX for only $99!

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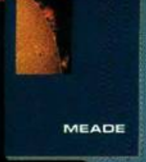
See the full-page Meade ad in this issue for complete terms and conditions of this amazing offer.



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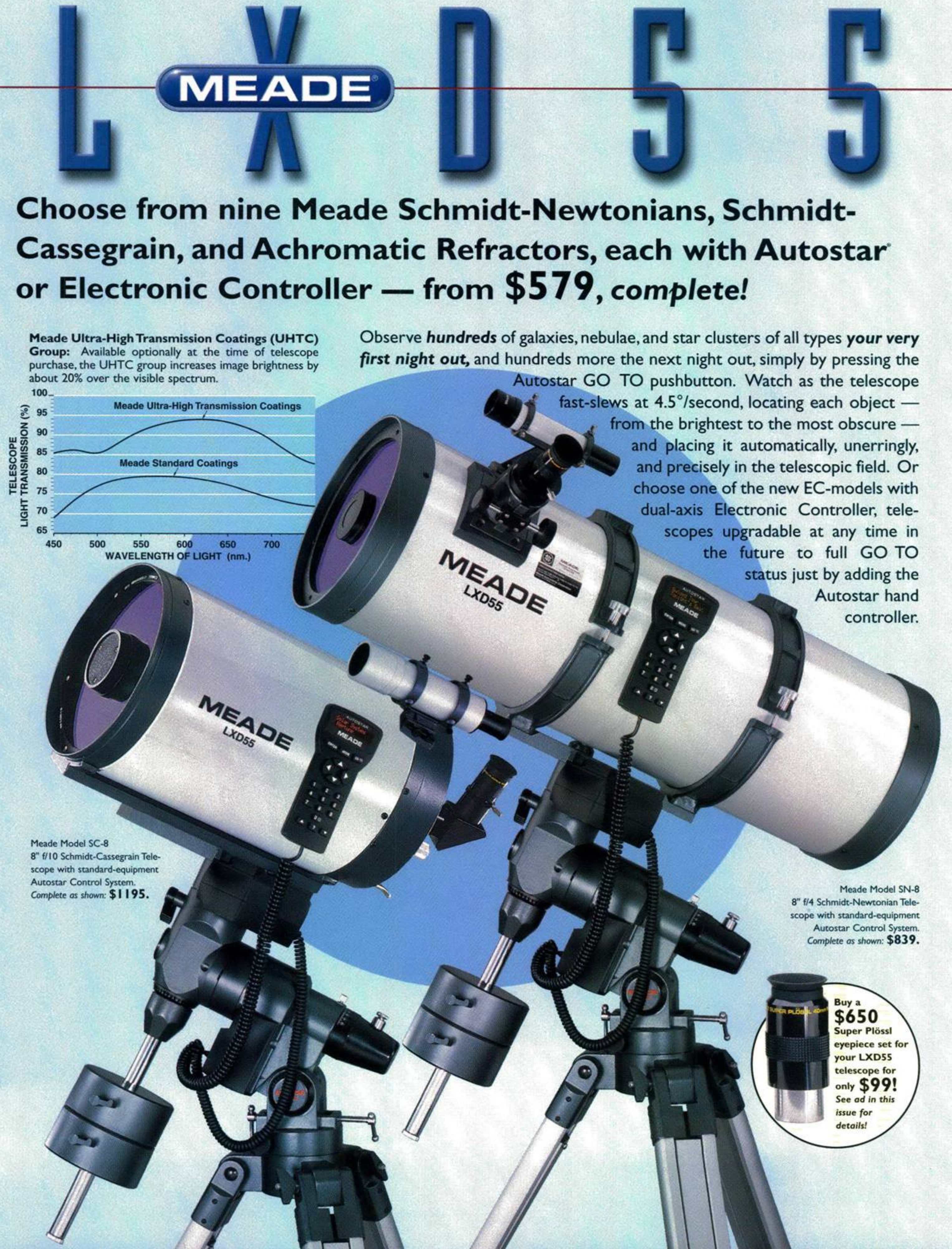


LXD55
MEADE
TELESCOPE LIGHT TRANSMISSION (%)
100
95
90
85
80
75
70
65
450
500
550
600
650
700
WAVELENGTH OF LIGHT (nm.)
Meade Ultra-High Transmission Coatings
Meade Standard Coatings
MEADE LXD55
AUTOSTAR
SUPER PLÖSSL 40mm

Choose from nine Meade Schmidt-Newtonians, Schmidt-Cassegrain, and Achromatic Refractors, each with Autostar® or Electronic Controller — from $579, *complete!*

Meade Ultra-High Transmission Coatings (UHTC) Group: Available optionally at the time of telescope purchase, the UHTC group increases image brightness by about 20% over the visible spectrum.

Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope fast-slews at 4.5°/second, locating each object — from the brightest to the most obscure — and placing it automatically, unerringly, and precisely in the telescopic field. Or choose one of the new EC-models with dual-axis Electronic Controller, telescopes upgradable at any time in the future to full GO TO status just by adding the Autostar hand controller.

Meade Model SC-8
8" f/10 Schmidt-Cassegrain Telescope with standard-equipment Autostar Control System.
Complete as shown: **$1195.**

Meade Model SN-8
8" f/4 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System.
Complete as shown: **$839.**

Buy a $650 Super Plössl eyepiece set for your LXD55 telescope for only $99! ***See ad in this issue for details!***

6", 8", and 10" LXD55-Series Schmidt-Newtonians with Autostar

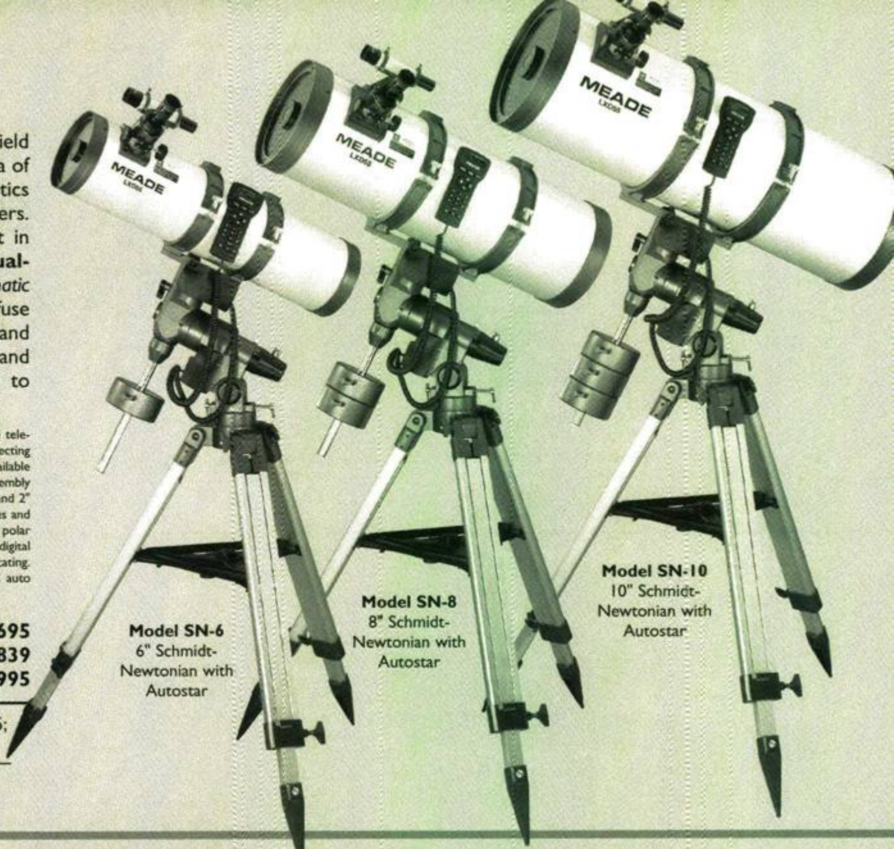
Meade American-made diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios. Fast f/4 (8", 10") or f/5 (6") optics present brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser resolution. The standard-equipment **Autostar Dual-Axis Control System** permits an amazing range of operations: *automatic GO TO capability* at 4.5°/second to 30,223 database objects (galaxies; diffuse and planetary nebulae; star clusters; the complete Messier, Caldwell, IC, and NGC catalogs; double and variable stars; eight major planets; asteroids; and comets); *nine selectable slew and slow-motion speeds* from 1x sidereal to 4.5°/sec.; plus *automatic sidereal-rate tracking* in RA, and much more.

SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); white-enameled metal optical tube with machined-aluminum mirror cell; quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12v DC auto cigarette lighter plug or from 115v AC home outlet); operating instructions.

6" Model SN-6 Schmidt-Newtonian	**$695**
8" Model SN-8 Schmidt-Newtonian	**839**
10" Model SN-10 Schmidt-Newtonian	**995**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95.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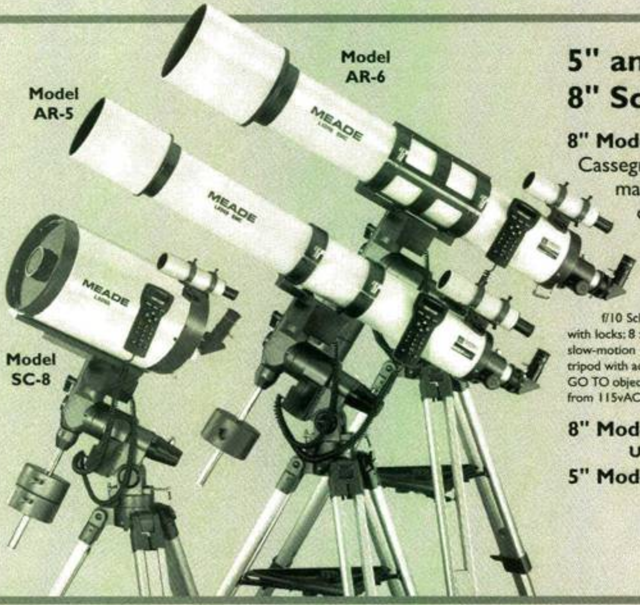
6" Schmidt-Newtonian with Autostar
Model SN-8
8" Schmidt-Newtonian with Autostar
Model SN-10
10" Schmidt-Newtonian with Autostar



5" and 6" LXD55-Series Achromatic Refractors and 8" Schmidt-Cassegrain with Autostar

8" Model SC-8: Includes the f/10 optical system of the Meade 8" LX200GPS for razor-sharp Schmidt-Cassegrain photo-visual imaging of the Moon, planets, and deep-space. All the telescope required by many amateurs for a lifetime of serious observing. **5" Model AR-5, 6" Model AR-6:** Excellent optical performance from the classical 2-element achromat design, with images rich in resolution and contrast and a minimum of chromatic aberration. Models SC-8, AR-5, and AR-6 allow for the full range of Autostar functions described above.

SPECIFICATIONS: Models SC-8 Schmidt-Cassegrain and AR-5 and AR-6 Achromatic Refractors — Each complete telescope includes 8" f/10 Schmidt-Cassegrain with MgF_2/standard coatings or 5" f/9 or 6" f/8 achromatic refractor with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 8 x 50mm viewfinder; Series 4000 Super Plössl 26mm eyepiece; diagonal prism. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

8" Model SC-8 Schmidt-Cassegrain	**$1195**
UHTC group for Model SC-8 — $175	
5" Model AR-5 Achromatic Refractor	**695**
6" Model AR-6 Achromatic Refractor	**895**

Packing & shipping charges in the 48 states: 8" – $85; 5" – $85; 6" – $95.

6" and 8" LXD55-Series Schmidt-Newtonians and 5" Achromatic Refractor with Electronic Controller

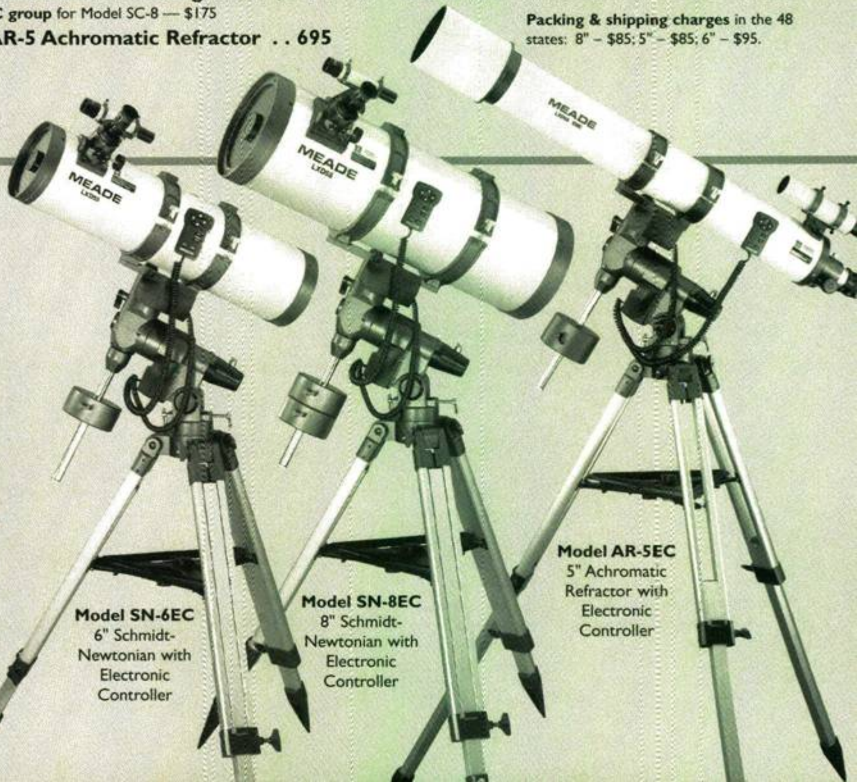
All the performance and features of the Autostar models above, but with 4-speed (2x, 8x, 32x, 4.5°/sec.) dual-axis Electronic Controller in place of Autostar. Upgrade to the Autostar Controller, available separately, at any time.

SPECIFICATIONS: Models SN-6EC, SN-8EC, and AR-5EC — Identical in every detail to the respective Models SN-6, SN-8, and AR-5, above, but with Electronic Controller (EC) in place of Autostar Hand Controller. Electronic Controller includes four dual-axis slewing speeds: 2x for photoguiding; 8x for image centering in the main telescope; 32x for image centering in the viewfinder; and 4.5°/second for rapid-slew of the telescope across the sky. ***#497 Autostar Controller may be added at any time in the future and, when plugged into the telescope's control panel, permits the full range of Autostar functions, including automatic GO TO, as described for Autostar-equipped telescopes, above.***

6" Model SN-6EC Schmidt-Newtonian	**$579**
8" Model SN-8EC Schmidt-Newtonian	**699**
5" Model AR-5EC Achromatic Refractor	**579**
#497 Autostar Controller, for any EC-model above	**149**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6EC – $85; 8" Model SN-8EC – $125.

Packing & shipping charges in the 48 states: 6" SN-6EC – $75; 8" SN-8EC – $85; 5" AR-5EC – $85. All prices shown in this ad are suggested U.S. national mail-order retail prices. © 2003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6" Schmidt-Newtonian with Electronic Controller
Model SN-8EC
8" Schmidt-Newtonian with Electronic Controller
Model AR-5EC
5" Achromatic Refractor with Electronic Controller

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RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or studying tenuous nebulosity in deep-space, Meade SP's deliver unmatched contrast and image sharpness. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each: **$79.95** (4.54)
32mm (52°); **40mm** (44°)	each: **99.95** (5.26)
56mm (52°; 2")	**199.95** (7.02)

Series 4000™
2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™
Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

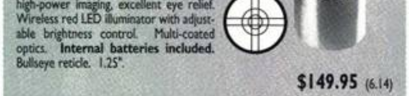
$129.95 (5.26)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm (*far right in photo*), an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm $79.95** (3.86)



Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels.

$16.95 (2.73)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

#911B
#911N
#908B
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

New! 2" Diagonal Mirrors with UHTC

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$119.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to *less than one second.* A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with **any** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

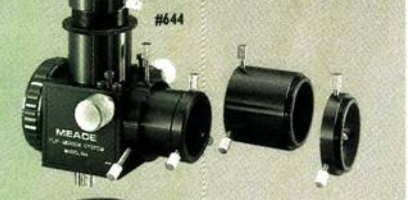
"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces.
$149.95 (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces.
249.95 (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.)
15.00 (3.86)

#644



#647

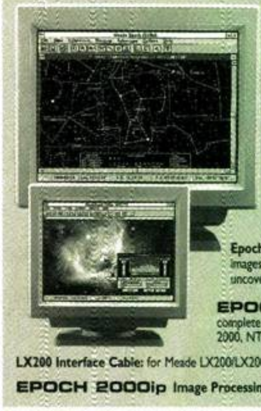
MEADE
FLIP-MIRROR SYSTEM

ELECTRONIC CONTROLLER
MEADE

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate hand-box for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries.

$249.95 (9.85)



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left)*: Use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** Dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely! Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software: Enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP **$99**

LX200 Interface Cable: for Meade LX200/LX200GPS operation by Epoch 2000sk.......... **25**

EPOCH 2000ip Image Processing Software: On CD-ROM for Windows 95, 98, 2000, NT, and XP **99**

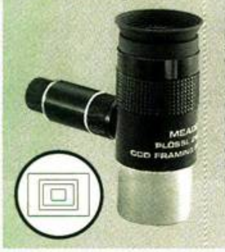
4000 f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular



Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

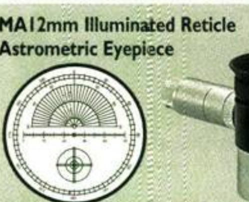
$34.95 (3.86)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

$49.95 (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25".

$119.95 (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25".

$219.95 (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models:
99.95 (8.58)

#776 Case for ETX-105EC:
99.95 (8.58)

#775 for ETX-125EC:
149.95 (13.38)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70 .... **19.95**
#673 for ETX-90........ **24.95**
#675 for ETX-105...... **27.95**
#678 for ETX-125...... **29.95**

MEADE
PICTOR

Pictor 216XT CCD Autoguider/Imager

The most advanced Autoguider/Imager in its price class. For many, all the CCD imager required for a wide range of lunar, planetary, or deep-space applications. Includes the same "point-and-shoot" simplicity of larger Pictor models. Produces smooth, natural 16-bit images of all celestial subjects. Also a precision autoguider during astrophotgraphy.

$695. (12.00)

Advanced Field Tripod for ETX-125

#887: Yields *rock-solid* stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

#889 Adapter: Available separately, permits attachment of ETX-125 to any Meade LX10 or LX200 Field Tripod or wedge. **$69.95** (7.70)

ETX® Deluxe Field Tripod

#884: Constructed of strong, lightweight steel; designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 25" to 43", for seated or standing observations. Graduated scale for elevation angle from 20° to 90° permits precise polar alignment of the telescope for astronomical applications. Tripod tilts and locks at 90° for terrestrial applications or for altazimuth use with Autostar. Telescope attaches to tripod in seconds with 2 thumbscrews. **Includes custom-fitted carry bag *(shown)* with pocket for accessories.**

$199.95 (10.00)

#771 Aluminum Carrying Case

High-quality, lightweight aluminum, suitable for storage of eyepieces, camera adapters, filters, etc. Fully foam-lined. 15" x 10" x 5".

$49.95 (5.78)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models: **$119.95** (6.85)

#1247 Electric Focuser for ETX-125 models:
$119.95 (6.85)

ELECTRONIC CONTROLLER
MEADE

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

ANACORTES TELESCOPE, Anacortes, WA.
Orders & Information: 800-850-2001.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

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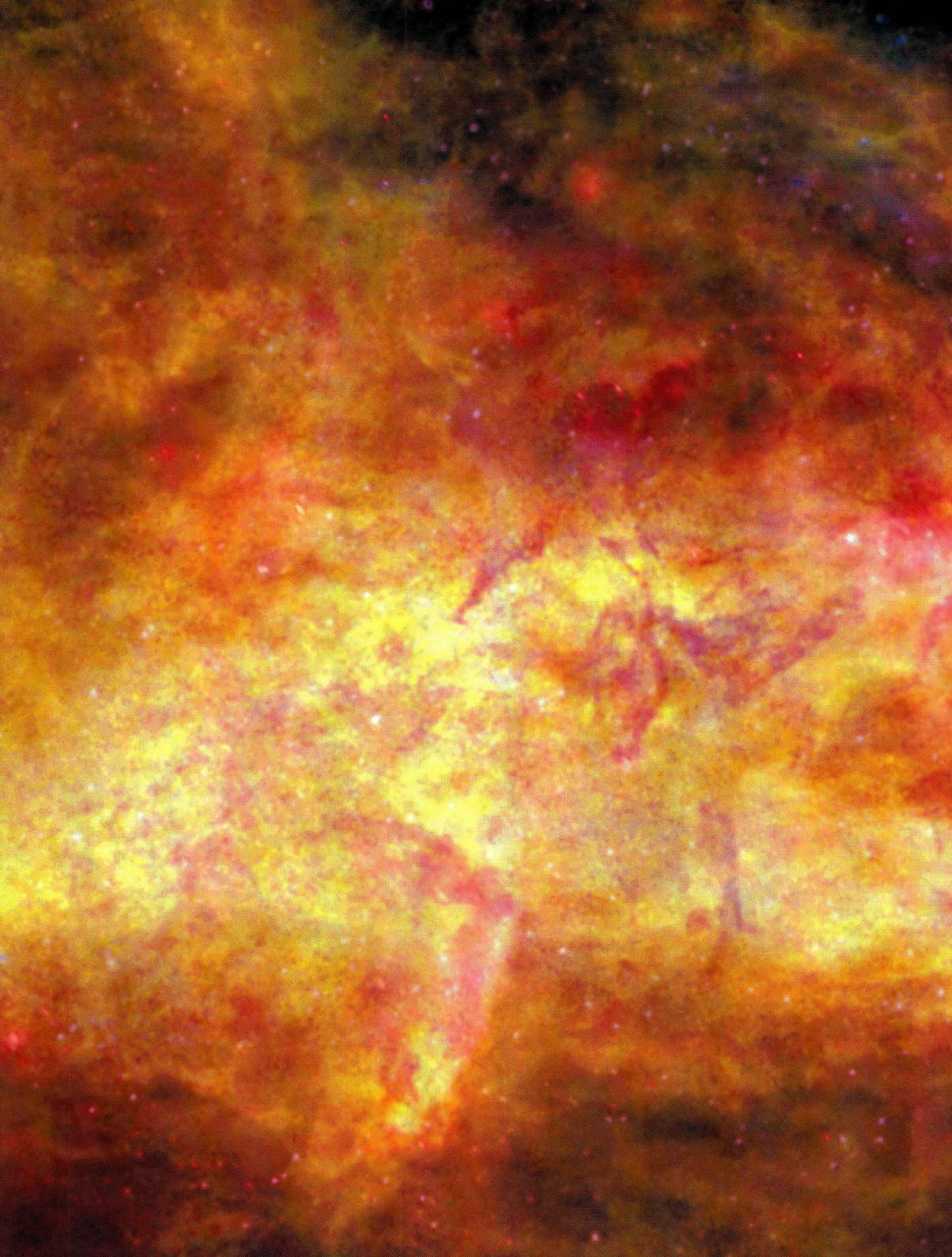

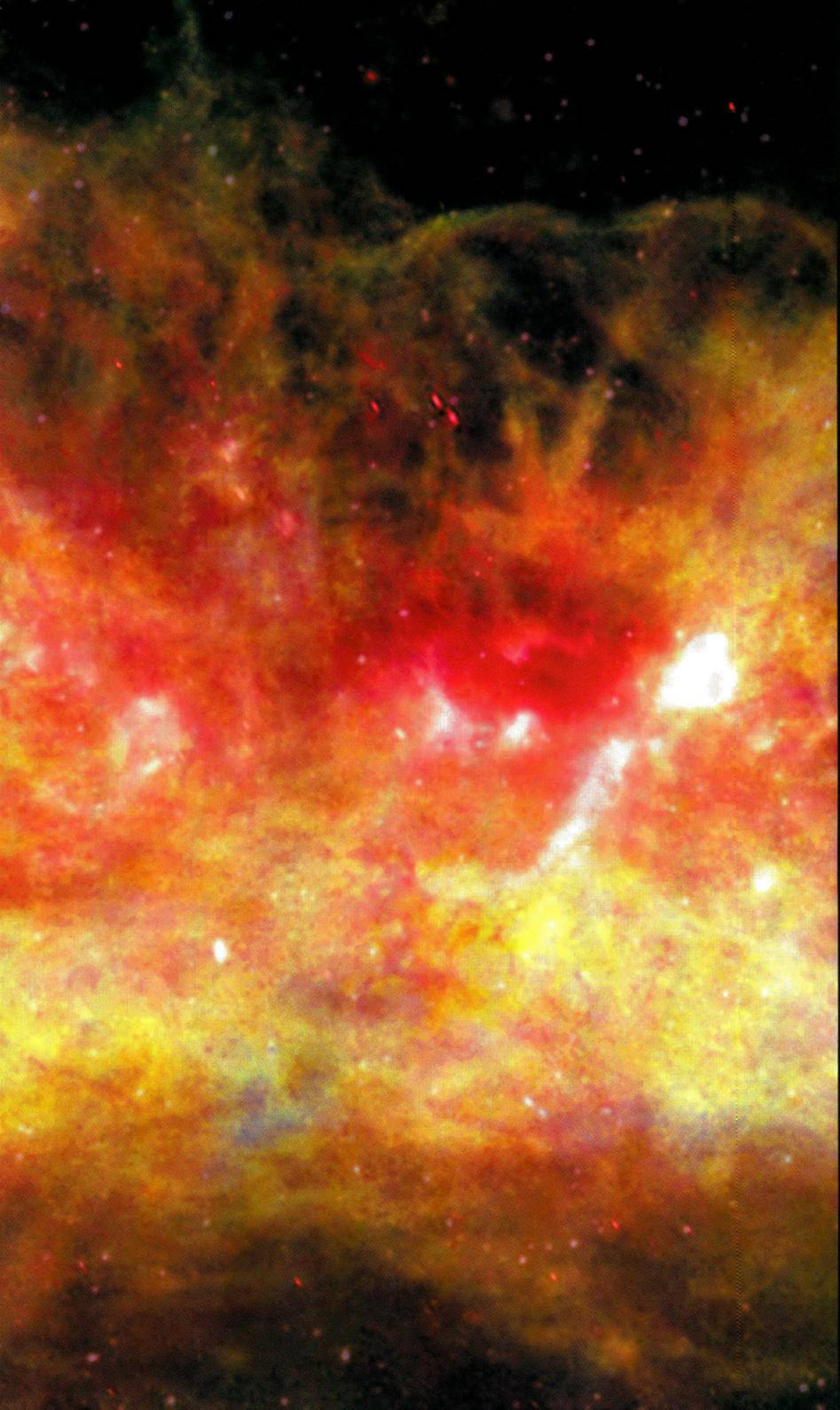

sky Gem

Scanning a Spiral Arm

Icy hydrogen gas fills the space between stars in our galaxy's Perseus spiral arm, which lies 6,500 light-years from Earth. The gas glows at radio wavelengths and dominates this Canadian Galactic Plane Survey image. Warmer dust radiating in the infrared appears reddish, while active galaxies in the distant universe show up as point sources.

Jayanne English (U. of Manitoba) using data acquired by the Canadian Galactic Plane Survey (NRC/NSERC) and produced with the support of Russ Taylor (U. of Calgary)

Anyone can sell you a telescope.

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Meade ETX-105EC
$695 ($770 w/UHTC)
Meade ETX-125EC
$895 ($990 w/UHTC)
#497 Autostar **$149**

Hardly a day goes by that we don't get a note or e-mail message like the one reprinted on the next page, or a call that goes something like this: "Your ads are right. Dealer so and so advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!"

If you want the right telescope, you need more than a camera store clerk armed with only a price list and a puzzled look when you ask questions.

What you *really* need are people who take the time to listen to what *you* need, people who answer your questions truthfully, people with years of experience using and selling telescopes who can help you get the most telescope for your dollar. That's exactly the kind of people you'll find at ***astronomics***. We have a combined total of 160 years of experience using and selling scopes!

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy telescopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. And, unlike department store clerks, we don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs . . . *and your budget* . . . from the hundreds of Celestron, Discovery, Meade, Questar, Stellarvue, Takahashi, TeleVue, TMB, and Vixen scopes we stock. And with our large inventory, we can usually ship you the right scope right away.

astronomics. No hard sell. No guesswork. Just honest advice, the *right* scope, and a good price. Call us at (405) 364-0858 and find out for yourself.

"Optics as good as I have seen . . . in any telescope . . . at any price."

A review in June's *Sky & Telescope* said the **TMB 100** 4" f/8 ED triplet apochromatic refractor had "optics as good as I have seen in any refractor, indeed in any telescope I've tested or used at any price." It just confirms what dozens of our very satisfied customers have been saying about their TMB apo refractors for months.

Not only do the TMB ED apo refractors have optically unsurpassed triplet optics and precision mechanics (such as a 3" focuser), but many of the sizes listed below are available from stock. Even those that may be temporarily out of stock are usually available again in few short months, not a few years, as is the case with another well-known brand.

Why wait years for another triplet apo when you can be observing with the best right now? For more details and pictures, visit our website to see the apo refractors that are the talk of experienced astronomers everywhere.

TMB 80/6 80mm (3.1") f/6	$\$1690^{00}$
TMB 80/7 80mm (3.1") f/7	1690^{00}
TMB 100 100mm (4") f/8	3290^{00}
TMB 105 105mm (4.1") f/6.2	3290^{00}
TMB 152 152mm (6") f/7.9	6990^{00}
TMB 175 175mm (7") f/8	$11{,}990^{00}$
TMB 203 203mm (8") f/9	$19{,}990^{00}$
TMB 254 254mm (10") f/9	$39{,}995^{00}$

Custom-built Dobs.

Astronomics offers custom-made truss tube Dobsonians hand-crafted by Pete Kron, a long-time Astronomics customer who is now a full-time member of our staff. Pete has been custom-building Dobs for over 15 years, in sizes up to a 36" f/5, and is known for using premium quality components. While Pete specializes in 18" through 24" apertures, custom mirror sizes and focal ratios are also available. He can also upgrade your bulky and unwieldy commercially-made Sonotube Dobsonian to an easily transportable truss tube version.

Prices start at $3500 for a custom-built 18" scope. Converting your commercially-made Sonotube Dob optics to a truss tube mount starts at $1500 for a 16" f/4.5 scope.

For more information, or to discuss specific pricing, you can contact Pete via e-mail care of questions@astronomics.com. You can also reach him by phone toll-free from 9 to 5 Monday through Friday at (800) 422-7876.

The new Meade LXD55 EC scopes . . . *add go-to when you need to.*

Meade
5" AR-5EC
refractor
$579

Some observers enjoy hunting for celestial objects the way the pioneering astronomers did – by eye, star hopping from object to object. Others want a go-to scope to do the hunting for them, but have a budget that says, "Can't afford a go-to yet." For both groups, the Meade LXD55 EC scopes are the answer!

The 5" EC multicoated achromatic refractor and fast focal ratio Schmidt-Newtonian 6" and 8" reflectors (with either standard or optional UHTC optics) are complete working scopes, with standard dual-axis DC drives and a four-speed/four direction EC hand control (which are costly options with competitive scopes). You can star hop or use setting circles to find objects. Once found, the scope tracks those objects automatically while you observe.

For the purist or the observer on a budget, they're all the scope you need now. *But* . . . just add an optional Autostar computer later and you have a fully computerized go-to telescope with 30,000 stars and objects in its memory. You can have as much or as little automation as you want, at a price you can afford *now!*

$729
Meade
8" SN-8EC
f/4 reflector
($854 w/UHTC)

Want the latest TeleVue telescope or eyepiece? We keep them all in stock.

Whether it's the newest telescope or the newest eyepiece (like the 3mm to 6mm Nagler zoom at $380), if it's from TeleVue, chances are good we have it in stock. Gibraltar, Panoramic, and TelePod mounts; Nagler, Radian, Panoptic, and Plössl eyepieces; Powermates and Barlows; Everbrite diagonals; and more – we have it all. Others say they carry TeleVue, but we actually keep it stock. Call us and see.

All packages come without a mount, but with an eyepiece, star diagonal, tube ring for mounting, and case. Basic optical tubes, without accessories, are also available.

NP-101, package, without mount	$\$3595^{00}$
TV-102, package, without mount	2635^{00}
TV-102, optical tube only	2200^{00}
TV-85, package, without mount	2080^{00}
TV-85, optical tube only	1680^{00}
TV-76, package, without mount	1675^{00}
TV-76, optical tube only	1275^{00}
Pronto, package, without mount	1120^{00}
Pronto, optical tube only	775^{00}

We carry Vixen. Great performance, sane prices.

For many years, the Vixen scopes from Japan have been European best-sellers. For years, they were also sold in the States by a famous U. S. manufacturer under that manufacturer's own name. They gained that manufacturer a reputation for optical and mechanical quality, but you could rarely buy Vixen scopes under the Vixen name at reasonable prices. Now they're finally available in the U. S. under the Vixen name by which they're known worldwide – and at sane prices. The importer is TeleVue, a company with a sterling repuation for quality of its own.

Whether it's a telescope, mount, or accessory, if it's from Vixen, chances are good we have it in stock. Lanthanum long eye relief and wide angle long eye relief eyepieces; Great Polaris and Great Polaris DX mounts; ED, Fluorite, and dual ED doublet apochromatic optical tubes and complete scopes; photo accessories; and more – we have it all. Visit our website for a complete listing of available stock or call us and see for yourself.

Vixen GP ED102S
4" f/9 ED apochromatic refractor
(shown with optional motor drive)

A $\$450$ bino for $\$179^{95}$? One couple bought 9!

One couple liked the $450 list **Celestron Tasco 8 x 42mm Rare Bird** roof prism binoculars they bought from us so much that they bought seven more to give to their kids and their spouses!

Armored, waterproof, multicoated, with BaK4 prisms, a soft case, wide neck strap, 6.6° field, and long 16mm eye relief. The Rare Bird is great for astronomy, birdwatching, sporting events, or just all-around family fun.

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Last but not least, we carry the **Thousand Oaks** broadband, narrowband, Oxygen III, and H-Beta filters in both 1.25" and 2" versions for eyepiece use.

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For detailed information on individual products, visit our Web site. You can call us at (405) 364-0858, or e-mail us, for your *free* copy of our catalog AST. It covers all the scopes and accessories we stock – from Bushnell, Canon, Celestron, Coronado, Discovery Telescopes, JMI, Losmandy, Meade, Nikon, Parallax Instruments, Pentax, Questar, Rigel Systems, SBIG, Software Bisque, Stellarvue, Takahashi, TeleVue, TMB, Vixen, and more. We'll include our guide on how to pick the right scope and your discount prices on the 1000+ products we carry. (Sorry, U. S. sales only.) The catalog is yours for only the cost of a one minute phone call. The information we send will make it the most useful minute you'll ever invest in astronomy.

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Meade 8" LX90
$1695

The 8" **Meade LX90** Schmidt-Cassegrains let you enjoy 8" go-to astronomy for not a lot of money. They're available from stock with either standard optics or the new optional UHTC optics.

The LX90 with standard optics is only $1695. The UHTC optics version LX90 (with up to 20% brighter images) is only $1870. Both have a heavy-duty adjustable height tripod, an Autostar go-to computer with a 30,223 star and object data base, a big 8 x 50mm finder, and a 26mm Super Plössl eyepiece.

We had 13 of the LX90 with UHTC in stock at the time this was written, so the chances are good you can get *your* LX90 with little or no delay. If Meade is shipping either LX90 *(or any Meade scope)* for a dealer to keep in stock, the chances are very good that we *have* it in stock.

Meade prices are about the same anywhere you call. So why order a Meade scope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade scope you want . . . right now . . . at the right price . . . right here at ***astronomics.***

8" and 10" Meade GPS UHTC scopes ship from stock. They do all the work so you can see 20% more.

Meade 8" LX200 GPS with UHTC
$2670

Never before have so many features been packed into one telescope series. The LX200GPS scopes – the widest variety of premium go-to telescopes on Earth – have all the features you've dreamed about since you started astronomy – plus optional UHTC (Ultra High Transmission Coatings) for up to 20% brighter images.

You get fully automatic GPS alignment with true north and true level sensors and automatic magnetic declination correction; a unique mirror lock to eliminate image shift during critical CCD imaging; a standard equipment 4-speed electric focuser; a built-in computer database of over 145,000 stars and objects; flashlight battery operation; and much more.

Meade GPS scopes with UHTC optics will let you see up to 20% *more.* Plus, you'll spend more time looking *at* celestial objects and less time looking *for* them. We had dozens of 8" and 10" LX200GPS scopes in stock as this was written. Chances are good we have one in stock for you.

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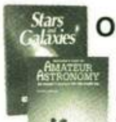

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Canon image-stabilized binoculars . . . a whole lot less shaking going on!

$100 rebate!
Canon

"Truly a quantum leap in binocular observing . . . particularly impressive was how well these binoculars compared to much larger apertures . . ." is what *Sky & Telescope* said about the Canon image-stabilized binoculars. There are no jittery images while hand-holding these binos, just rock-solid observing that reveals more detail than conventional binoculars. From a compact 8 x 25mm handy for travel and birding to a big 18 x 50mm that's excellent for astronomy, there's an image-stabilized Canon binocular that's right for you – ***and you get a rebate of up to $100 from Canon!*** You'll find full details on our website.

Last chance to get 14 Celestron accessories for $99!

Through December 31, buy *any* Celestron telescope, and we'll send you a $399 package of Celestron eyepieces and filters for only $99! You'll get fully multicoated 1.25" Plössl eyepieces in focal lengths of 4, 6, 9, 15, and 32mm; a fully multicoated 1.25" 2x Barlow; a 1.25" neutral density Moon filter; #12 medium yellow, #21 orange, #25A medium red, #56 light green, #58A dark green, and #80A medium blue 1.25" eyepiece color filters; and an aluminum case to hold them – for only $99!

The full details of this sensational Celestron limited time $99 offer can be found on our website at **www.astronomics.com**.

> Just a short note to thank you for your help in assisting with my 8" SCT purchase. I appreciate the time, patience, and thoughtfulness of your answers to my questions. It's a pleasure to do business with someone who shows as much knowledge and interest as you.
>
> **Customer Quote of the Month #130**

Eyepiece storage cases from $2.49.

Bolt-type containers protect eyepieces dew and dust. Foam inserts cradle eyepieces to protect them from accidents. Our website at **www.astronomics.com** lists which eyepieces fit into which containers (including other containers not listed below).

42mm x 60mm holds most Celestron NexStar, Meade Series 3000, and TeleVue Plössls. **$2.49**
52mm x 80mm Holds TeleVue Radians, Nagler 6, most Barlows, large Celestron Ultimas, etc. **$3.49**
65mm x 80mm Holds most illuminated reticles, 22mm Panoptic, 12mm Nagler, etc. **$3.99**

The NexStar 11 got a rave review. You can have yours next week!

NexStar 11 GPS
$2999

Celestron's 11" go-to GPS scope – the **NexStar 11 GPS** – got a *rave* review in *Sky & Telescope.* The review gave it "an enthusiastic two thumbs up and a gold star." They said it has "brains and good looks. The NexStar 11 GPS puts Celestron's time-tested 11-inch f/10 Schmidt-Cassegrain optics in a sleek new package that includes some of the most advanced electronics ever offered in a mass-produced telescope . . . Celestron is the first to take Go To scopes to the next step in their evolution, and it's a nice step indeed."

Multicoated optics are standard with the NexStar 11 GPS (other brands charge extra). We have the NexStar 11 in stock (34 as this was written). Call us and you can be observing with yours in about a week.

Multicoated optics are free on the NexStar 8 GPS.

NexStar 8 GPS
$2499

The in-stock 8" Celestron **NexStar 8 GPS** (28 on hand as this was written) has Starbright high transmission multicoated optics for brighter images at no extra cost. And you can easily convert its unique Fastar optics to a blazingly fast f/1.9 focal ratio for wide field CCD imaging.

With an optional Fastar lens assembly and a $1295 SBIG ST-237A CCD camera, the NexStar 8 GPS will record a huge 32 x 42 arc minute field. That's larger than the full Moon and more than three times the sky area imaged by a $7695 camera on other 8" scopes without Fastar!

Of all the computerized GPS scopes, *only the NexStars have multicoated Fastar optics at no extra cost!*

The new Celestron Modular i Series 8" GPS SCTs starts at only $1199!

NexStar 8i
$1199
shown with optional tripod and computer

If you compare, you'll see that the new **Celestron NexStar 8i** go-to costs less than comparably-equipped competitive 8" scopes. Starting at only $1199 for a complete working tabletop scope (not even available from the competition), you can add the options that you, and your budget, feel comfortable with. An *iCOMP* computer hand control with 40,000 deep space objects in memory is $149. A light weight travel tripod is $149. A heavy duty tripod (same as the NexStar 11 GPS) is $299. If you want the convenience of GPS auto-alignment, add it for only $199. However you outfit your NexStar 8i, it's enough scope to keep you observing for the rest of your life, at prices that leave competitive scopes behind.

A 5" GPS-ready scope starts at $899!

The **Celestron NexStar 5i** is the first 5" telescope to have a fully automatic GPS go-to computer available as an option. No other 5" scope has a GPS system! Even better, the modular nature of the NexStar 5i means that you can build up to a fully automatic GPS system gradually, starting at only $899 for a complete working tabletop scope. And multicoated optics are standard equipment with the NexStar 5i, not an extra-cost option as with other brands. NASA uses 5" Celestron multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium images?

The Stellarvue refractor is a "hot new product."

AT1010A **$499.95**
shown w/optional diagonal and eyepiece

The 80mm f/6 **Stellarvue AT1010** achromatic refractor was named "Hot New Product of 2001" in the December 2001 issue of *Sky & Telescope.* Even better, independent user reviews say it competes favorably with ED semi-apochromatic telescopes that cost twice its modest price, and that it easily outperforms imported achromatic scopes in color correction and resolution. The AT1010A has hand-assembled and triple tested optics, tube rings, tripod adapter, 2" focuser with both 1.25" adapter and T-threads, red dot finder, oversize rubberized focus knobs for easier use in cold weather, and a soft padded carry case. It's a super deal and it's in stock to ship now.

Sell your used telescopes and accessories quickly by using the classified ads you can run *for free* at

www.astrofieds.com

Discovery Dobsonian reflectors start at only $339.

8" f/6 DHQ
$449

Why settle for an imported Dob when you can have made-in-the-USA quality *for less money!* Discovery doesn't use imported, mass-produced optics that are merely spot-checked to see if they're acceptable. Discovery optics are made in California by optical craftsmen, one quality mirror at a time. Each is hand figured to diffraction-limited performance, and it doesn't leave the Discovery optical shop until it's right.

Each DHQ series Dob has an adjustable metal primary mirror cell, a true *thin vane* adjustable 4-vane diagonal mirror spider, *two* Plössl eyepieces, a built-in tube balancing system, a tube carry handle, new oversized bearings, a 6 x 30mm finder, and a dust cover. You can get an upgrade kit that adds two more Plössl eyepieces, an eyepiece rack, a second dust cover, and a Moon filter for only $49 more!

Premium Dobs from 10" to 17.5" in aperture are also available. And for those who need big aperture portability, truss-tube Dobs are available in apertures from 12" to 24". Here are the Discovery 6" to 10" DHQ Dob prices:

6" f/5 Discovery DHQ	**$339.00**, plus $49 freight
6" f/8 Discovery DHQ	**$339.00**, plus $49 freight
8" f/6 Discovery DHQ	**$449.00**, plus $49 freight
8" f/7 Discovery DHQ	**$449.00**, plus $49 freight
10" f/4.5 Discovery DHQ	**$649.00**, plus $69 freight
10" f/5.6 Discovery DHQ	**$649.00**, plus $69 freight

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TALKING BACK
FROM OUR READERS

Orion – Not Just a Nebula?

The dictionary defines "Orion" as "a giant hunter slain by Artemis in Greek mythology," or "a constellation on the equator east of Taurus." Astronomy buffs commonly associate the term with M42, the Orion Nebula. But who would have guessed it was also the name of a French resort? Just ask Bob Rubin of the NASA-Ames Research Center, who has celebrated the fact that "Orion" has become a slogan for everything from shoes to VCRs. As an astronomer who studies the Orion Nebula, Rubin collects anything and everything he can find — newspaper ads, business cards, candy bar wrappers — that feature "Orion" as a slogan or title. Over the years, he (and his colleagues who have gotten in on the act) have collected more than fifty examples, which now adorn Rubin's office door. To take a peek at his collection, visit his website, http://www-space.arc.nasa.gov/~rubin/orioncollection1.html. — Astronomy *editors*

M42 provides for just one of the many uses of the term "Orion." George Greaney

Praising Sagan

I have been subscribing to *Astronomy* for many years and look forward to reading it every month. The features on Carl Sagan's *Cosmos* in the September issue were brilliant. The articles served as a wonderful homage to this monumental work. I was almost as thrilled to read about *Cosmos* as I was to watch the series twenty years ago. I will always miss Sagan, who was an inspiration to all of us. — *Rowan Partridge, Tolga, Australia*

Wonders of Technology

I was amazed at the photo of NGC 604 in M33 (September, page 81), taken with a 16-inch SCT. The photo includes surrounding stars within M33. Wow! Edwin Hubble labored long and hard through many freezing nights at the 100-inch Hooker scope on Mt. Wilson to record faint images of stars in the Andromeda Galaxy (M31), thus proving that spiral nebulae were separate galaxies and that the universe consisted of more than just our Milky Way. And now, much less than a century later, an amateur can do about the same in a little over three hours with a scope only 16 percent the size of the Hooker scope. Isn't CCD technology wonderful? — *Keith Hood, San Antonio, Texas*

Is that Varuna?

I enjoyed reading *Astronomy*'s annual *Explore the Universe*, especially "Astronomy's Top Ten." But I believe I found a small error on page 13: The caption identifies the circled KBO in the photo as Varuna, whereas I discovered that under a magnifying glass the name beside the object reads "2001 KX76," which is the other KBO discussed in the article. This goes to show that despite all the high-tech equipment available today, low-tech tools such as magnifying glasses still hold their ground in the quest for knowledge. — *Daniel Rey Martnez, Bogotá, Colombia*

Correction

On page 82 of the October issue, the website listed for "The Nine Planets" is incorrect. The correct address is http://www.seds.org/nineplanets/nineplanets/nineplanets.html.

Astronomy invites you to talk back. Send letters to Astronomy Talking Back, P.O. Box 1612, Waukesha, WI 53187; e-mail to talking@astronomy.com. Letters may be edited for space or clarity. If you want to talk back to us, please visit our website, http://www.astronomy.com.

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Alaskan aurora photograph by Mike O'Leary

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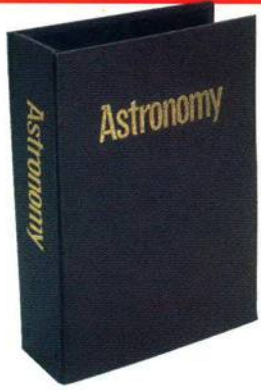

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"We ran through the alignment procedure during evening twilight and observed throughout the entire night without missing a beat...and every object that we commanded the scope to point at ended up in the field of a low-power eyepiece."

"The optics in the NexStar loaned to us were some of the finest I can recall in a Schmidt-Cassegrain, but if anything the optics in the scope we purchased at random were even better."

–Dennis di Cicco
"The NexStar 11 GPS: Beauty and Brains"
Sky and Telescope
February 2002

A telescope that combines the design features, engineering, performance, and value of the NexStar® 11GPS doesn't come out of the *Blue*.

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Here's why: Compare the design features and construction of the NexStar 11GPS (as well as the NexStar 8GPS) to the competitor's 12", 10", and 8" GPS telescopes. Every component of the NexStar 11GPS, from its rugged integrated drive base and fork arm design to the unique carbon fiber optical tube assembly has been designed specifically for this model NexStar telescope. Only Celestron matches and meticulously hand-figures each individual telescope optical system.

Understanding Resolution.

Do coatings affect resolution? No! When comparing telescopes, it's extremely important to clearly understand the relationship between coatings and resolution. ***Fact: Resolution is a function of aperture. Coatings only affect light transmission.*** It is a function of aperture or diameter of the objective lens. Rayleigh's Criterion defines resolution as: $\theta = 1.22 * \lambda / D$, where λ is the wavelength of light, D is the diameter of the objective lens, and θ is the resolution in radians. Image brightness is a function of aperture, focal ratio, and system's light transmission efficiency. ***StarBright® coatings have been standard on all of our Schmidt-Cassegrain telescopes since 1983 AT NO ADDITIONAL COST.*** For primary and secondary mirrors, StarBright coating is a precise multilayer application of Al, SiO_2, TiO_2, and then another layer of SiO_2 — all to maximize reflectivity. On the corrector lens we apply precise layers of MgF_2 to both surfaces to maximize transmission.

The dark-adapted (scotopic) eye's peak sensitivity is at 510nm. The sensitivity drops off dramatically on either side of 510nm. In fact, as the wavelength approaches 400nm, the eye's sensitivity goes to almost 0%. The same is true as the wavelength goes to 600nm. Celestron's StarBright® Coatings are designed to peak at 510nm, the peak sensitivity of the scotopic eye. Celestron offers these coatings at no additional cost to the consumer. The chart below shows the transmission at 510nm for both Celestron and competitor's large aperture SCT telescopes.

Transmission at 510nm for all Celestron large aperture SCT's and competitor's SCT's

NexStar 8"	87%	No Additional Cost
NexStar 9.25", 11", 14"	85%	No Additional Cost
Competitor's Standard Coatings - all SCT's	77%	No Additional Cost
Competitor's UHTC	86%	**Cost: $175 (8"), $235 (10"), $295 (12")**

Competitive information obtained from December, 2002 issue of *Sky and Telescope.*

NexStar 11GPS. Quality from the inside out.

Carbon Fiber Tube — ***Strong and lightweight with 1/4 of the thermal expansion of an aluminum tube. Scratch and dent resistant.***

Optical Tube Assembly Outer Rails — ***An outer rail on each side of the optical tube provides rigid, flex-free movement. Mounting tolerance allows cell to contract and expand.***

NexStar quality and reliability. Designed in. Not added on.

COMPARISON OF DESIGN FEATURES

This chart compares the significant design and engineering features of the NexStar 11GPS with competitor's 10" and 12" GPS telescopes.*

Feature/Specification	NexStar 11GPS	Competitor's 10"	Competitor's 12"
Mirror Coatings	StarBright*; 5-step multilayer	Standard; (Enhanced Coatings $235)	Standard; (Enhanced Coatings $295)
Fork Arm	Dual fork tine cast aluminum with integrated hand control receptacle. Fork arms are long enough to permit optical tube to swing through	Dual fork tine cast aluminum; hand control attaches to fork arm with external bracket.	Dual fork tine cast aluminum; hand control attaches to fork arm with external bracket; fork arms not long enough to allow optical tube to swing through
Leveling Technique	Internal switch - levels the tube to the mount to the accuracy of 1 arcminute; Usable for both Alt/Az and equatorial	Ground level switch; only useful for Alt/Az	Ground level switch; only useful for Alt/Az
Cord Management	Internal slip ring design. Power is mounted to non-rotating part of drive base. Accessory ports rotate with top of drive base	Requires internal hard stops to avoid tangling and disconnecting wires; accessory ports do not rotate with telescope which can cause cords tangling	Requires internal hard stops to avoid tangling and disconnecting wires; accessory ports do not rotate with telescope which can cause cords tangling
Carrying Handles	Ergonomically designed for ease of lifting	Attached to front of fork arms	Attached to front and back of fork arms
Motors	Pittman mfg. in U.S.A.;12V DC Servo; quiet	Unknown; very noisy	Unknown; very noisy
Gears	Berg mfg. in U.S.A.; 5.625" precision bronze gears on both axes; 180-tooth; mated with stainless steel worm shaft	5.75" aluminum gears on both axes	5.75" aluminum gears on both axes
Bearings	9.5" roller azimuth bearing	4" dia. polar bearings	4" dia. polar bearings
Focusing Mechanism	Two (2) preloaded ball bearings	Bushing and washer	Bushing and washer
Optical Tube	Carbon Fiber; reduces thermal expansion; 4x less than aluminum	Aluminum	Aluminum
Fastar Compatible	Yes	No	No
Weight of Telescope	63 lbs.	62 lbs	75 lbs
GoTo Precision	1.5 arcminutes	2 arcminutes	2 arcminutes
Boot-up Time	1-1.5 sec.	20-25 sec.	20-25 sec.
GPS Alignment Time	2.5 min.	More than 4.5 min.	More than 4.5 min.
Quick Align	Yes	No	No
Database Filter Limits	Automatic filter limits for named objects list	No database filter limits for custom object lists	No database filter limits for custom object lists
Price**	**$2,999 + $125 S&H = $3,124**	**$2,495 + $145 S&H + $235 for Enhanced coatings = $2,875**	**$2,995 + $215 S&H + $295 for Enhanced coatings = $3,505**

How you can tell wrong from right.

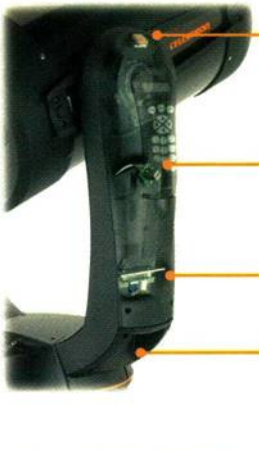
Celestron strongly believes that the only way to design and manufacture our NexStar GPS telescopes is the ***right way***. The right way means understanding what expectations our customers have when they make an investment in our products, and designing and manufacturing telescopes that meet or exceed their expectations. That means paying attention to details and not cutting corners. Compare the following examples of why we believe that we have designed the NexStar 8GPS and 11GPS the right way and what we believe is wrong with the design of the competitor's GPS telescopes. Consult the chart to the left for an additional comparison.

Wrong:

- The competitor's GPS antenna is partially obstructed by the finderscope.
- When the base rotates, cables can easily wrap around the fork arms and become entangled.
- Carrying handles are poorly designed and located making it difficult to lift the telescope.
- Boot-up time can take as much as 20-25 sec.
- Hand control displays objects below the horizon.
- Motors and gearbox are noisy.
- The competitor's 10", and 12" drive base is undersized.
- The OTA (Optical Tube Assembly) on the competitor's 12" will not swing through and clear the drive base; the fork arms have spacers to attach to the base.
- The complete optical system is not hand-figured.
- The hand control is attached to a bracket with the cable hanging loose.
- Enhanced coatings do not increase resolution.
- Focus mechanism uses bushings intead of ball bearings.

Right:

- Celestron's GPS antenna is not obstructed by the finderscope.
- Celestron's drive base design eliminates any potential for cord/cable wrap.
- Carrying handles are integrated into fork arms to make lifting and transporting easier.
- Boot-up, alignment are fast and easy.
- Hand control has many advanced features and is user-friendly; only shows objects above the horizon.
- High quality precision gearing ensures quiet, precise operation.
- Large diameter drive base and bearing track provides maximum stability. Especially important when equatorially mounted.
- Carbon fiber tube minimizes thermal expansion/contraction; important for astrophotography or CCD imaging.
- Mirror shift minimized through use of precision bearings.

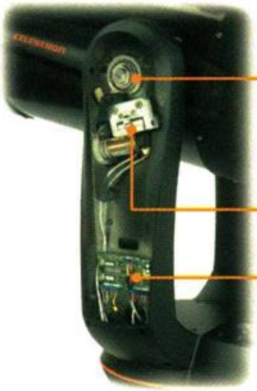


16-channel GPS — ***Interference free. Finderscope is positioned away from GPS antenna. Pinpoints your exact location on Earth with an unobstructed view.***

Upgraded hand control and software features — ***40,000 object database; new features include compass calibration, polar alignment routine, EQ AutoAlign, database filter limits, hibernate, Auto north and level, wedge align algorithm, Quick Align, user-defined slew limits.***

Electronic compass — ***Finds true North when used in conjunction with NexStar software.***

Ergonomically designed fork arm with integral handles — ***Integrated handles in fork arms designed for ease of carrying and safe and easy setup and transportation.***



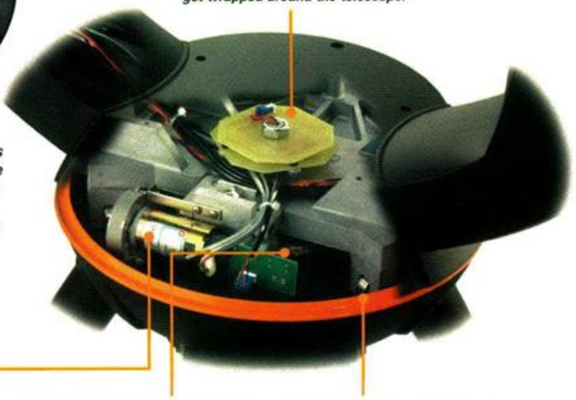
Bearing and shaft — ***Heavy-duty preloaded tapered roller bearing on both axes.***

Worm shaft — ***Stainless steel worm shaft has .4375 pitch diameter and is preloaded with two ball bearings. The worm is made from a single piece of steel to minimize run-out, which is the source of periodic error.***

Heavy-duty aluminum spring loaded worm block — ***On both axes; minimizes backlash.***

Motor board — ***Each axis is controlled by its own 8-bit microcontroller.***

Auxiliary Ports — ***The NexStar's auxiliary ports are located on the top of the base which rotates as the telescope turns preventing accessory cables from wrapping around fork arms.***



Internal Slip Ring — ***The NexStar's power cables will never wrap and telescope accessory cables will not get wrapped around the telescope.***

Drive Motors — ***Made in the U.S.A., Pittman Lo-Cog™ brush commutated DC motors offer smooth, quiet operation and long life. The motor armatures are skewed to minimize cogging which is required for low speed tracking. Windings are resin impregnated for greater reliability in incremental motion application.***

Precision bronze gear — ***32 pitch, 5.625" pitch diameter, 180-tooth bronze gear. Manufactured in the U.S.A. by W.M. Berg, Inc. Manufactured to AGMA Quality Class 10 standard which minimizes total composite error and backlash.***

Unique roller bearing design — ***Base rotates around a wide 9.5" track for maximum stability; especially important when equatorially mounting for imaging.***

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* Version Tested: 1.0b Telescope Serial #01039 All comparative information obtained from User Manual for this model.

**Prices obtained from December, 2002 issue of *Sky & Telescope*
Set-up Information: Starting Position: Alt.= -90 and Az =0
Date: 09.18.02 Time: 8:00 PM (no daylight savings) Long: 118 West Lat: 34 North

KUIPER BELT OBJECT

Giant Iceball Found Beyond Pluto

The outer part of our solar system is a cold, dark place, littered with chunks of ice and the gas-giant planet Neptune. It seems fitting that a planet named after the god of the sea should play shepherd to a herd of icebergs collectively called Kuiper Belt Objects (KBOs).

The planet Pluto ranks as the largest of these objects, measuring 1,485 miles (2,390 kilometers) in diameter. New to this family is a giant ball of ice and rock dubbed "Quaoar" (pronounced kwa-whar) by its discoverers. This new world has a diameter of about 800 miles (1,300 km) and lies 4 billion miles (6.5 billion km) from Earth — more than a billion miles beyond Pluto.

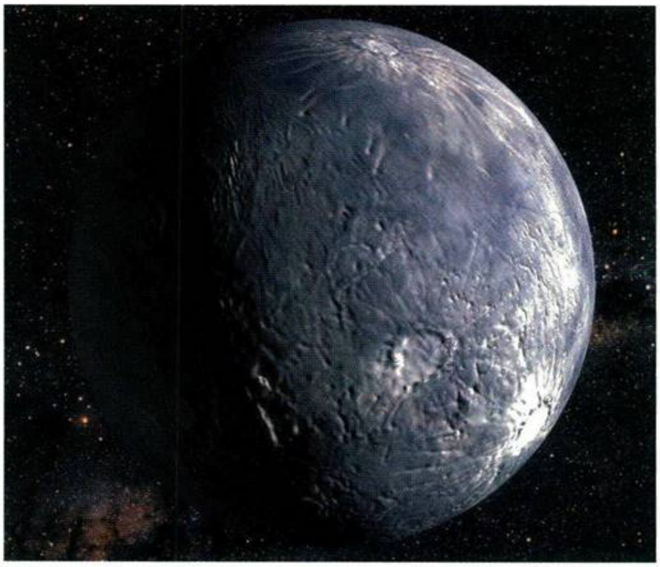
KBOs were initially theorized in the 1950s, and the first (non-Pluto) KBO was discovered in 1992. Over the past decade, more than 500 have been found. Quaoar is the most distant one to be resolved as more than a point of light. This is possible only because of its large diameter, which is second only to Pluto. The next three largest KBOs are Pluto's moon Charon, with a diameter of 737 miles (1,186 km), followed by Varuna and an object called 2002 AW197, which have diameters of about 560 miles (900 km).

Caltech scientists Michael Brown and Chadwick Trujillo discovered Quaoar using the Oschin Schmidt Telescope on Palomar Mountain in California, and determined its diameter with the Hubble Space Telescope's new Advanced Camera for Surveys. With an angular size of just 40 milliarcseconds, it is too small to be resolved by any current Earth-bound telescope.

Quaoar's official designation is 2002 LM60, and it won't be recognized as Quaoar until the International Astronomical Union approves the name. In general, objects in this part of the solar system are named after gods. Brown and Trujillo chose Quaoar to recognize a creation god of the Tongva tribe, which originally inhabited the Los Angeles basin. According to legend, Quaoar "came down from heaven; and, after reducing chaos to order, laid out the world on the back of seven giants. He then created the lower animals, and then mankind."

Quaoar will certainly add fuel to the debate over calling Pluto a planet. With Pluto just twice the diameter of Quaoar, should Pluto lose its planetary status, should icy worlds like Quaoar be added to the planetary roll call, or should Pluto's historical role continue to give it a unique status? However you choose to classify it, this new world beyond Pluto seems certain to be only the first of its kind. Brown predicts that within a few years even larger KBOs will be found.

— Pamela L. Gay



This artist's illustration shows what the large Kuiper Belt Object Quaoar may look like. It may well have craters and cracks caused by collisions with smaller KBOs.

NASA and G. Bacon (STScI)

Hubble's Advanced Camera for Surveys took these 16 snapshots of Quaoar. The telescope's sharp optics resolved the object's disk, leading to a measurement of its diameter of about 800 miles.

NASA and M. Brown (Caltech)

CRAB NEBULA

The Crab's Inner Workings

Charles Messier thought so highly of it that he placed it first in his famous catalog of deep-sky objects. But even he — who was simply making a list of objects that looked like comets but weren't — could never have imagined the significance of the Crab Nebula.

Unknown to Messier, the Crab Nebula (M1) is the shattered remains of a massive star that blew itself up. Witnessed by Chinese astronomers in 1054, the supernova appeared so bright it could be seen in daylight for several weeks.

By the latter part of the 20th century, astronomers had begun to learn many of the Crab's secrets, yet failed to make much headway in understanding the nebula's inner sanctum, where rapid changes in details at the limit of resolution conspired to thwart their best efforts. Now a team of researchers led by Jeff Hester of Arizona State University has used the combined power of the Hubble Space Telescope and the Chandra X-ray Observatory to examine the tempest in the heart of the Crab.

Hubble imaged the Crab's center in visible light on 24 occasions between August 2000 and April 2001, while Chandra observed the Crab's x rays eight times between November 2000 and April 2001. Hester's

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- **Filter Limits** — Displays only those objects within the set altitude filter limits. Works the same as NX 8GPS and 11GPS except the hand control displays a warning if there are no objects within the set filter limits.
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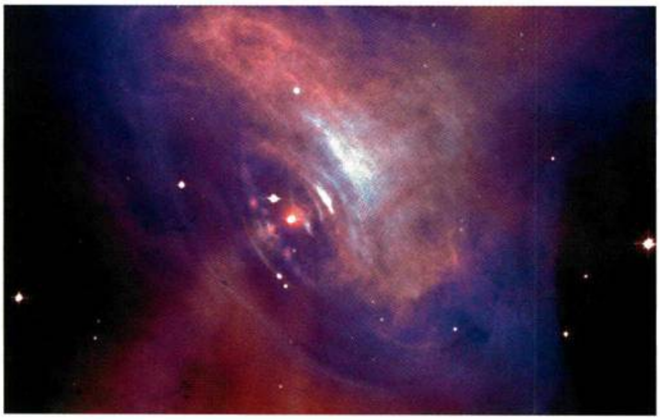


High-speed winds and shock waves fill the turbulent inner region of the Crab Nebula in this recent composite that combines an optical image from Hubble (seen in red) with an x-ray image from Chandra (in blue). The Crab pulsar appears as a white dot near the center of the image.

NASA/HST/CXC/ASU/J. Hester et al.

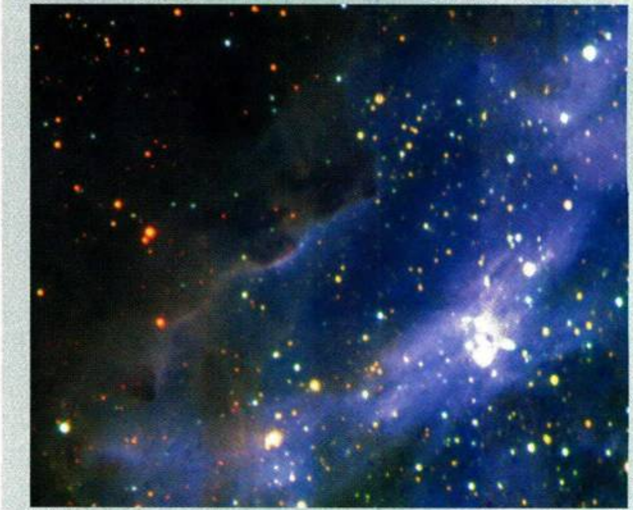
team then created movies from all the still images. The scientists reported their results in the September 20 issue of *Astrophysical Journal Letters.*

"The Crab Nebula has now come to life," says Hester. "We can see how this awesome cosmic generator actually works." Bright wisps moving at half the speed of light can be seen forming an expanding ring in both the optical and x-ray views. The wisps appear to originate in a shock wave that forms a bright inner ring surrounding the Crab pulsar — the crushed remains of the exploded star that emits pulses of radiation 33 times every second.

The pulsar generates huge electrical voltages that accelerate matter and antimatter particles outward along its equator. As this high-speed wind plows into the surrounding nebula, it creates the shock wave that forms the ring, which consists of about two dozen knots that form, brighten, and fade. "These data leave little doubt that the inner x-ray ring is the location of the shock wave that turns the pulsar's high-speed wind into extremely energetic particles," says team member Koji Mori of Penn State University. Those particles then move outward to brighten the outer ring and produce an extended x-ray glow.

Another impressive feature of the latest images is a turbulent jet that spews energetic particles from the pulsar's poles, perpendicular to the rings. Violent motions inside the jet can be seen, along with a slow motion outward that transports energy into the surrounding nebula. — Richard Talcott

UK INFRARED TELESCOPE



Joint Astronomy Centre

NEWBORN STARS FIGHT TO SHINE through the dense clouds of gas and dust that still permeate the Omega Nebula (M17) in Sagittarius. Located some 5,500 light-years from Earth, the Omega ranks among the most prolific star-forming regions in the galaxy. Ultraviolet radiation from young, hot stars excites the interstellar gas clouds. This causes them to glow brightly, as seen in blue at the lower right of the image. The radiation can penetrate only so far, however, before being attenuated so much that it stops destroying the cloud. The sharp transition between light and dark that runs diagonally across the image distinguishes that region. The dark side represents the original gas cloud, a treasure-trove for astronomers who study star birth. This image captures the Omega's infrared radiation and marks "First Light" for a new imaging spectrometer on the United Kingdom Infrared Telescope on Mauna Kea.

X-RAY ASTRONOMY

Jets from a Black Hole

▶ Jets are one of nature's favorite ways of spewing matter around. Often associated with quasars and active galaxies, x-ray jets are observed streaming away from the supermassive black holes that inhabit the centers of distant galaxies. Although these jets travel at near the speed of light, they are so big that we cannot observe their creation and evolution in a single human lifetime. While astronomers use computers to model these systems, nature has also kindly provided an observational "toy model": nearby stellar mass black holes with quickly evolving jets.

In September 1998, the Rossi X-ray Timing Explorer satellite caught a black hole binary in the process of forming jets. Located some 17,000 light-years from Earth in the southern constellation Norma, the system known as XTE J1550–564 has given researchers their first opportunity to watch a pair of x-ray jets form and expand. A team of astronomers led by French scientist Stephane Corbel reported in the October 4 issue of *Science* on its observations with NASA's Chandra X-ray Observatory and the radio telescopes of the Australia Telescope Compact Array.

"Watching these jets slow down and disappear is like watching a time-lapse movie of the rise and fall of the Bronze Age," says Corbel.

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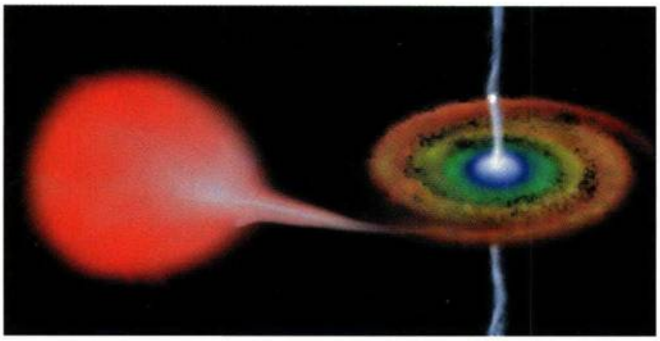
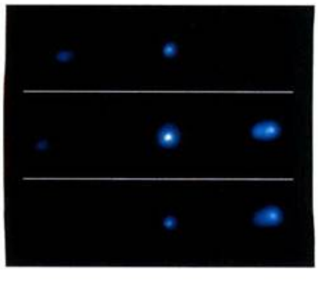


The gravitational pull from the stellar mass black hole XTE J1550–564 is so great that it strips material off its sunlike companion. This material forms a disk, parts of which can collapse and trigger runaway nuclear reactions that brighten the entire system and create jets of high-energy electrons that stream off the black hole's poles. CXC/M. Weiss

"Since the jets came from a stellar black hole in our galaxy, we saw in a few years developments that would have taken thousands of years to occur around a supermassive black hole in a distant galaxy."

Many black holes have surrounding accretion disks. In galaxy cores, this disk consists of gas and dust that has fallen into the galaxy's center. Stellar mass black holes in binary systems create their disks by gravitationally stripping material from their sunlike companions. Periodically, parts of a disk may collapse, causing nuclear reactions that brighten the system. When this occurs, high-energy electrons are jettisoned from the poles of the system's magnetic field, creating jets.

Chandra imaged XTE J1550–564 in September 2000 (top), March 2002 (middle), and June 2002 (bottom). X rays from the black hole appear at center; the jets at right and left brighten and fade over time. NASA/CXC

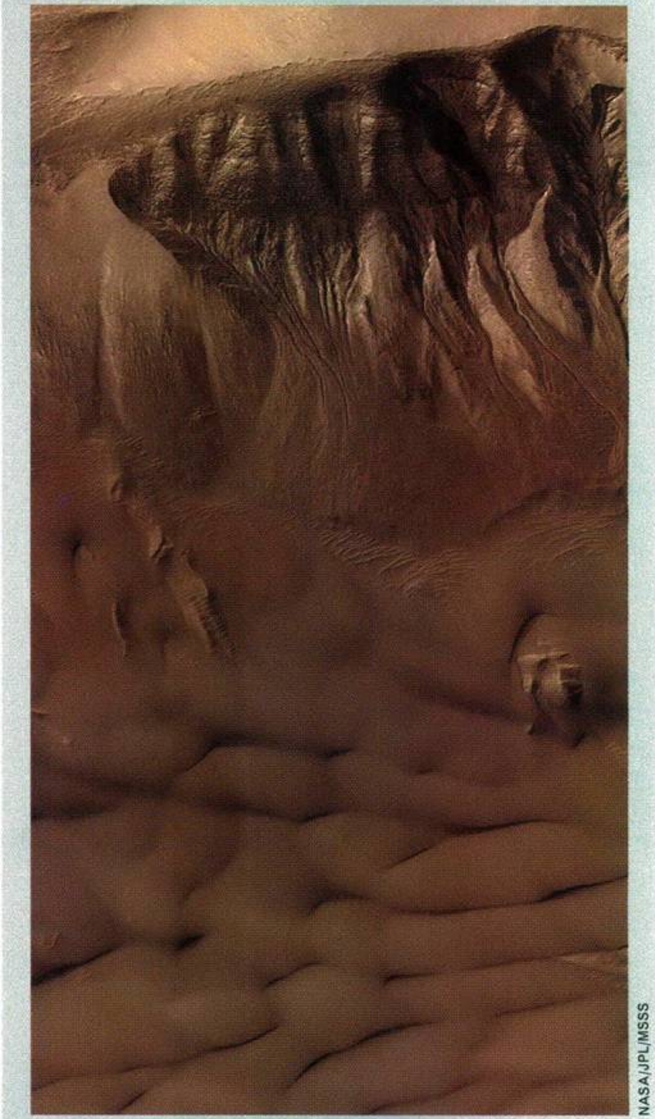


XTE J1550–564's jets initially raced away at nearly half the speed of light. Four years after their birth, they are now more then 3 light-years apart. Recently, the eastern jet has begun to fade.

"This poses a puzzle. The simple model for jets doesn't explain what we are seeing," says Philip Kaaret of the Harvard-Smithsonian Center for Astrophysics, lead author of an upcoming article in *The Astrophysical Journal*. "Either the black hole may somehow be feeding more energy into the western jet, or that jet has run into a dense cloud."

As material rushes through space, it interacts with gas and dust and loses energy as friction slows it down. Although astronomers think all jets decelerate this way, the observations of XTE J1550–564 mark the first time jets have been caught in the act of slowing. The observed deceleration underscores the value of studying small, stellar black holes in our galaxy. This system may hold the key to understanding the workings of distant quasars and active galactic nuclei. — P. L. G.

MARS GLOBAL SURVEYOR



NASA/JPL/MSSS

DEEP GULLIES DIG into the wall of a martian crater in this recent image from the Mars Global Surveyor spacecraft. The unnamed crater lies in Newton Basin, which is part of Sirenum Terra in the southern hemisphere of Mars. The gullies all seem to originate in a single layer of soil and may have formed in geologically recent times when groundwater escaped to the martian surface. This high-resolution wintertime image also reveals patches of frost on the crater wall as well as extensive sand dunes on the floor. This is one of more than 18,000 Global Surveyor images released this past October. It raises the total number of images released since the spacecraft arrived at Mars in September 1997 to 112,218 — more than twice the number returned by the two Viking orbiters in the 1970s.

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APOLLO 12 MISSION

Our Surprising New Satellite

Most of us alive on November 24, 1969, remember that as the day when Apollo 12 returned to Earth. And Alan Bean, Pete Conrad, and Richard Gordon did splash down in the Pacific Ocean that day, ending the second manned mission to the Moon's surface.

But part of the Apollo 12 spacecraft took a more circuitous route home. The third stage of its Saturn V launch vehicle returned this past April, temporarily giving us a new satellite — and the only one known to have been captured into Earth orbit from a solar orbit.

The latest chapter in Apollo 12's saga began September 3, when Canadian amateur astronomer Bill Yeung spotted a mysterious, slow-moving object. Designated J002E3, it quickly drew the attention of astronomers around the world.

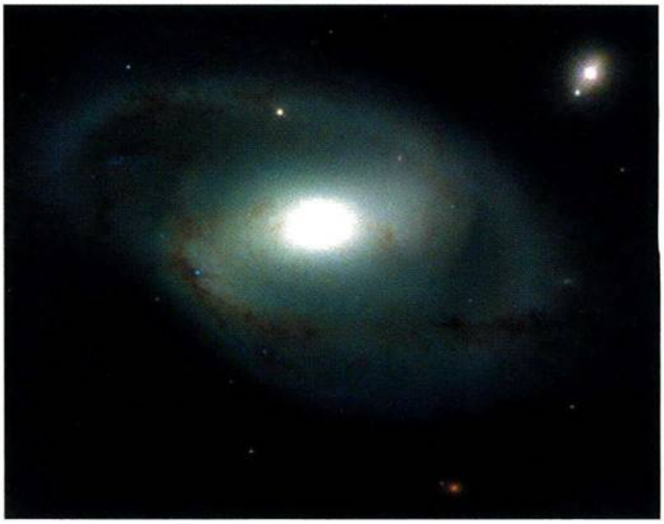
It took only a few weeks of observations to pin down J002E3's orbit. Paul Chodas of NASA's Jet Propulsion Laboratory calculated that the object had been orbiting the Sun until April, when Earth captured it. Extending the motion even further back, Chodas learned that it had escaped from Earth orbit in March 1971. Both transitions happened through a "portal" known as the L1 Lagrangian point, a spot about a million miles from Earth in the direction of the Sun where the gravitational pulls from the two objects are nearly equal.

Although an asteroid couldn't be ruled out, Chodas thought J002E3 might be the third stage of Apollo 12's Saturn V. Astronomers Carl Hergenrother and Robert Whiteley of the University of Arizona and Richard Binzel and Andrew Rivkin of MIT helped solidify the case by taking the object's spectrum. "Rather than looking like a known asteroid," says Hergenrother, "the colors were consistent with an object covered with white titanium oxide paint" — exactly the kind used on the Saturn V's upper stages.

Chodas says the peripatetic piece of space junk won't stick around forever. "This type of orbit can't last long," he states. "J002E3 will certainly depart the Earth-Moon system in June 2003." It could come back again, but the first chance won't be until the mid-2040s.

Within several thousand years, J002E3 will likely crash into Earth or the Moon. There's no need to fear this destiny, however. The spent third stages of the first three Apollo flights long ago disintegrated harmlessly when they re-entered Earth's atmosphere, and those from the final five missions were intentionally crashed into the Moon so scientists could measure their seismic impact. — R. T.

The third stage of Apollo 12's Saturn V launch vehicle (seen here before its 1969 launch) has been recaptured by Earth. NASA



The nearby galaxy NGC 4319 lies much closer than Markarian 205 (top right), a distant quasar that just happens to lie along the same line of sight. NASA and the Hubble Heritage Team (STScI/AURA)

GALAXIES AND QUASARS

A Cosmic Coincidence

The human eye is highly skilled at finding patterns, even when the patterns arise from chance alignments. This is useful when trying to avoid tigers hiding in tall grass but can cause grief to astronomers trying to interpret images. The pairing of NGC 4319 and Markarian 205 is a prime example.

First cataloged in the 1960s, Markarian 205 is a relatively nearby quasar. Located 1 billion light-years away, it's close enough that we can see its host galaxy. If you look carefully at a recent Hubble image (above), you might even make out a faint finger of luminosity reaching from the quasar toward the main galaxy, NGC 4319, located just 70 million light-years from Earth.

Differences between photographic film and current digital technology made this ghostly filament appear more prominent on early photos. Halton Arp and some other astronomers believed that this apparent bridge indicated a physical association between the two objects. If this were the case, it would radically alter the way we look at quasars. Arp contended that the enormous radial velocities exhibited by quasars came about because they were ejected from galaxies. Most others believed quasars attained their velocities by lying at vast distances and being carried away by the expansion of the universe.

With modern equipment, astronomers can see and measure the velocities of small galaxies near quasars, such as the bright blob next to Markarian 205. They find these companions to have the same large velocities as the quasars, proving that quasars are extremely distant and bright galaxies. The finger in Arp's photos was nothing more than the chance alignment of a disrupted patch of galaxy, no more or less important than other protrusions scattered around its edge. — P. L. G.

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BLACK HOLES

Dark Heart of a Globular

▶ After 30 years of searching, two teams of astronomers have used the Hubble Space Telescope to discover a new class of black hole. These intermediate-size black holes have been found in two globular clusters, a surprise that should lead to a better understanding of the formation of both black holes and globulars.

A team led by Roeland Van Der Marel of the Space Telescope Science Institute found a black hole about 4,000 times the mass of the Sun at the heart of M15, a globular cluster about 32,000 light-years away in Pegasus. The other team, headed by Michael Rich of the University of California, Los Angeles, located a 20,000-solar-mass black hole in the core of G1, some 2.2 million light-years away in the Andromeda Galaxy.

Previously, astronomers knew two types of black holes: supermassive black holes (millions to billions of times more massive than the Sun) in the hearts of galaxies and stellar-sized black holes that form when a massive star collapses.

Since the 1970s, astronomers have tried to find black holes between these two extremes, but the limited resolution of ground-based telescopes prevented success. "It's very exciting to finally find compelling evidence that nature knows how to make these strange beasts," says Luis Ho of the Carnegie Observatories, codiscoverer of the black hole in G1.

The teams discovered the black holes by observing the motion of stars near the center of each cluster. M15 lies close enough that Van Der Marel's team could study individual stars, while Rich's group examined the collective motion of groups of stars. The astronomers realized that a large gravitational force must be yanking on the stars and were able to calculate a mass for each unseen object.

The Hubble observations also show a correlation between the mass of the globular cluster and the black hole at its center. Hubble previously found that a black hole at a galaxy's center typically contains about 0.5 percent of its galaxy's mass. Amazingly, the newfound black holes also share this mass proportion with their clusters, even though they are hundreds of thousands of times lighter than the most massive black holes known.

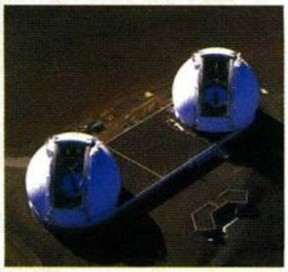
This relationship suggests that a fundamental process underlies the formation of black holes, globular clusters, and galaxies — one that astronomers don't yet understand. — Vanessa Thomas

The globular cluster M15 contains a modest black hole at its center, the first intermediate-mass black hole ever discovered. NASA and the Hubble Heritage Team (STScI/AURA)

For the latest astronomy news as it breaks, visit us at www.astronomy.com

Spend a Night on the Keck Telescope

The Astronomical Society of the Pacific is holding a fundraising auction for an observing night on the world's largest optical telescope, the W. M. Keck Observatory in Hawaii. The highlight of the five-day/four-night trip for two is the opportunity to spend a night with astronomer Geoff Marcy and his team — discoverers of more than 70 of the approximately 100 extrasolar planets known — in the Keck I control room in Waimea. Marcy will host dinner that evening, and the winner will be able to sleep overnight at the Visiting Scientists' Quarters. The auction package includes round-trip airfare for two, resort accommodations, car rental, meals, and a behind-the-scenes VIP tour of the Keck Observatory. The auction will be held in January 2003 on a popular auction website. The winner can schedule the trip to coincide with any of Marcy's planned observing nights in 2003. For complete details, potential bidders should visit the ASP website at http://www.astrosociety.org.



Richard Wainscoat/IfA

The Keck Telescope will host a lucky amateur observer.

Toward a Better Clock

If traditional atomic clocks don't satisfy your need for accuracy, a new one developed at NASA's Jet Propulsion Laboratory may do the trick. In a normal atomic clock, atoms are held in a glass vacuum chamber. Yet they sometimes collide with the chamber's walls, getting distorted and causing the clocks to run fast or slow. The new clock employs an ion trap, which uses an electric field to hold mercury atoms with one electron removed. Ions colliding with this "wall" are disturbed far less. The new clock will keep time accurately to one minute in 10 billion years.

Astronomers Win Nobel Prize

Three astronomers will share the Nobel Prize in Physics for 2002. Riccardo Giacconi won "for pioneering contributions to astrophysics, which have led to the discovery of cosmic x-ray sources." The father of x-ray astronomy, Giacconi discovered the first such source in 1962 with a rocket-borne detector and developed the first dedicated x-ray satellite, called Uhuru. Raymond Davis, Jr. and Masatoshi Koshiba won "for pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos." Davis built a huge detector for neutrinos — particles that rarely interact with matter — and placed it in a South Dakota mine. Over 30 years, he captured 2,000 solar neutrinos, proving that the Sun shines by nuclear fusion. Koshiba built Japan's Kamiokande detector, which captured neutrinos from Supernova 1987A, proving it resulted from the collapse of a massive star.

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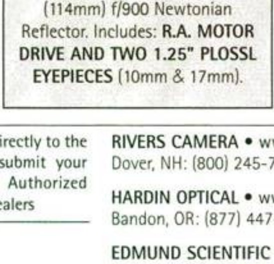

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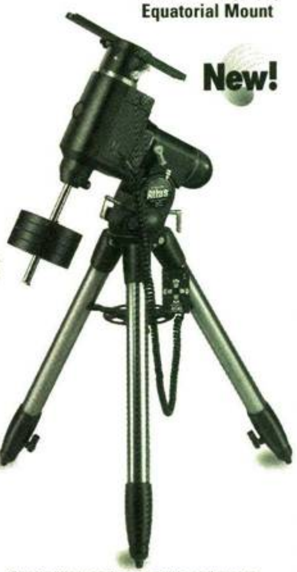

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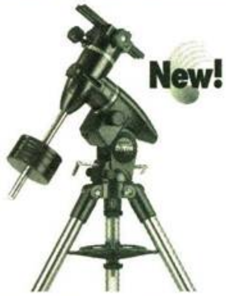

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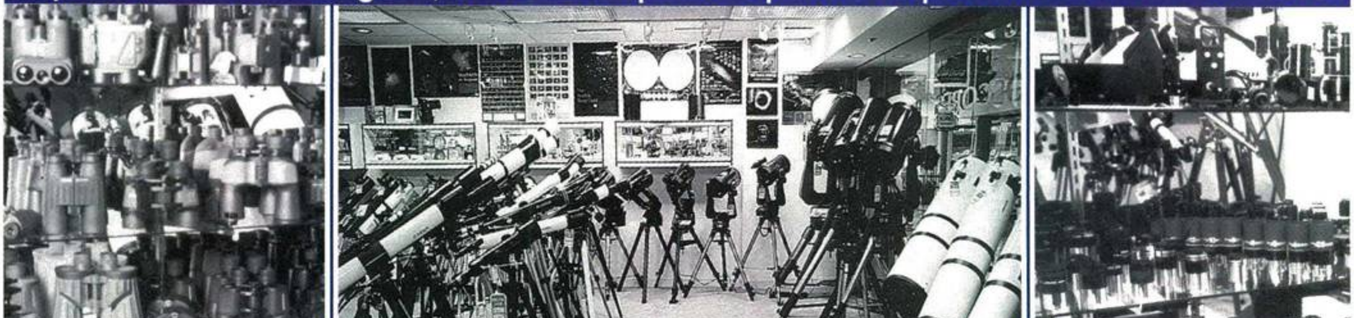

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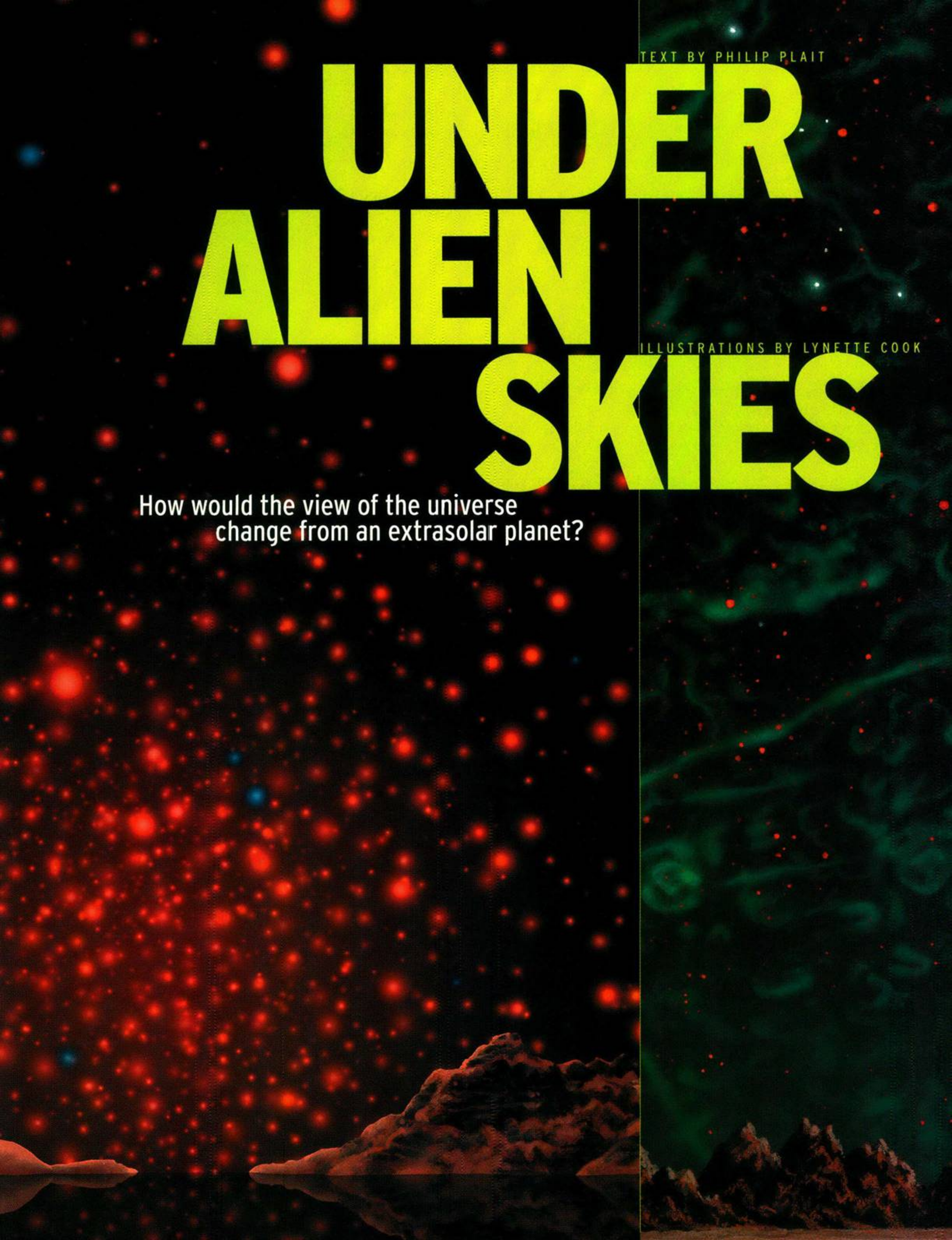
TEXT BY PHILIP PLAIT

UNDER ALIEN SKIES

ILLUSTRATIONS BY LYNETTE COOK

How would the view of the universe change from an extrasolar planet?



JUST BEFORE A TYPICAL SUNSET ON EARTH, THE SUN APPEARS SCORCHING white, the sky a deepening shade of blue. As you watch, the Sun slowly sets to the west, gradually turning orange, then fiery red. The sky gradually changes from azure to purple, and the stars appear one by one as night descends. With the sky dark about an hour later, you can see more than a thousand stars.

But would it be like this everywhere throughout the universe? How would the sky appear from an extrasolar planet?

The sky we see is the product of a very specific set of circumstances — Earth's rotation rate, the type of star the Sun is and our distance from it, and even our place in the galaxy. But if we were to drastically change the factors — replace the Sun with a red dwarf, for example, or put the solar system near a large nebula — how would this affect what we see?

While it is impossible to know for sure, we can make educated guesses based on the knowledge we have about objects such as nebulae, globular clusters, and dwarf stars.

How would "alien skies" differ from our own?

ORION NEBULA

On a planet circling a sunlike star just one light-year from the Orion Nebula, the sun is a scorching white, the sky a deepening shade of blue. As you watch, the sun slowly sets to the west, gradually turning orange and then fiery red. After the sun finally sets, the sky changes from azure to purple, and a cluster of four stars becomes shockingly bright. As full night descends, stars pop into view by the hundreds. Perhaps an hour later, with the sky fully dark, you can see thousands of dull red stars, set into a greenish maze of eerily glowing lines and sheets of light.

Stars are born in a particularly dense type of nebula called a molecular cloud. The biggest stars are very hot and pour high-energy ultraviolet photons into the dense cloud. The UV photons break up the molecules in the cloud into their constituent atoms, and the resultant gas of atoms forms a giant bubble. A cavity forms inside the nebula, expanding by eating its way into the denser cloud around it.

If the hot star at the heart of this expanding bubble is not at the center of the molecular cloud, the bubble will reach one edge of the cloud first and pop through. The hot, high-pressure gas inside the bubble then bursts out of the cloud, like champagne flowing from a newly opened bottle. Over time, the expanding gas thins, leaving behind a giant scoopmark in the face of the cloud.

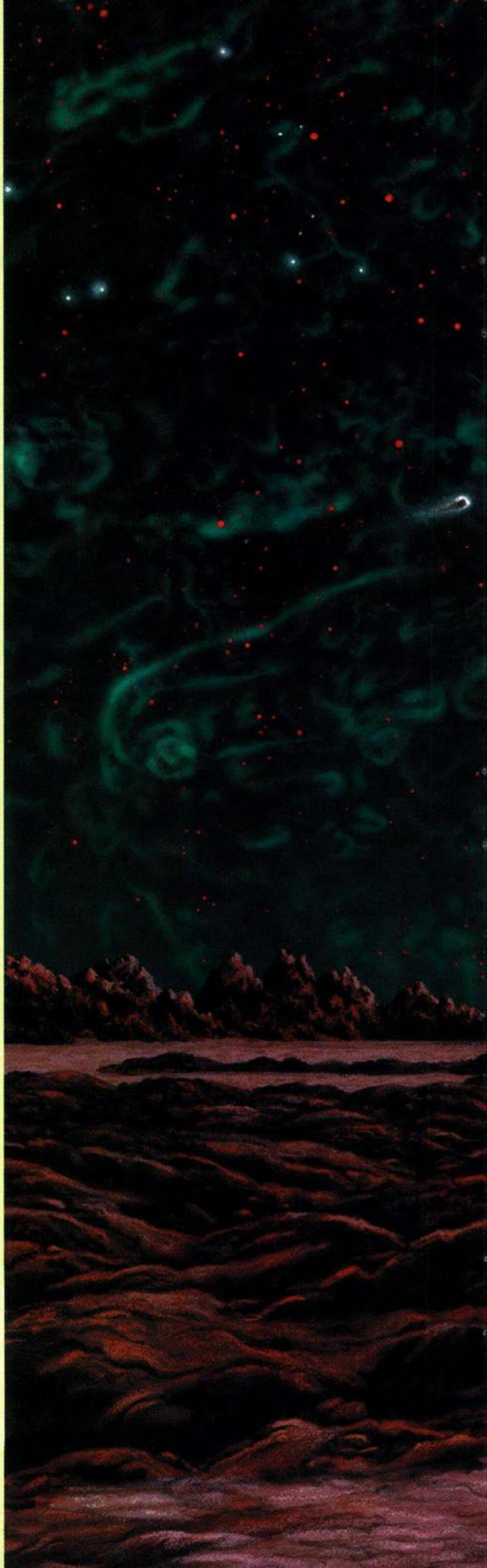
The Orion Nebula is the nearest example of this. From our vantage point, some 1,400 light-years away, we see four such giant stars, called the Trapezium, which have eaten their way out of the molecular cloud. These fresh young stars have carved a gigantic cavity many light-years across in the cloud. The tremendous luminosity of the stars lights up the cavity like a gigantic movie screen, illuminating what was otherwise a dark nebula. Much of the beautiful detail in the nebula, visible to us through a telescope, is actually the brightly lit molecular cloud.

But not all of it. Although no longer confined inside the cloud, the stars are still eroding the cavity wall. The heated nebular material expands in a rushing torrent of gas, flowing at speeds of up to 200 kilometers per second. It slams into surrounding material, creating shock waves that compress and heat the nebula further. The expanding gas emits light as well.

In most nebulae, including Orion, this gas is almost transparent to most types of visible light. From our safe distance on Earth, we get an overview of the nebula: a network of compressed sheets and filaments from the thin gas, punctuated with stars, superposed on the clumpy but still pervasive backdrop of glowing gas from the dense cloud.

From Earth, the visible part of the nebula is about the same size as the Full Moon in our sky. But from one light-year, the nebula would cover *half the sky*. The wall of the cavity would glow brilliantly, and the detail visible only through a telescope on Earth would be obvious to the naked eye.

The filaments and sheets of gas in the nebula are compressed by the shock waves flowing through them. These wisps can be so thin, in fact, that



their emission would *not* get spread out. From a nearby planet they would still be quite bright, and the sky would be criss-crossed with a fine network of interwoven ghostly green tendrils. Dotting this grid would be hundreds of stars, newly born from the forge of the nebula. Most of these would look ruddy, since interstellar dust absorbs bluer light, allowing only red light through.

But even this bizarre sight might not grab the attention of an onlooker, as the Trapezium would dominate the sky. From one light-year away, the brightest of the four stars would shine at a staggering 300 times brighter than Venus and would easily be visible in daytime. The other three stars would appear only marginally fainter.

The four stars would form a lopsided diamond spanning 9° across its longest dimension, about the size of your fist held at arm's length. Oddly, since we are viewing them from the opposite side of what we would from Earth, they would appear reversed when viewed from our nearby planet. Objects around you would cast four shadows, and even a glance at the stars would dazzle the eye, a reminder of how different the universe appears with a change of distance and perspective.

RED DWARF

On a planet circling near a red dwarf, the sun is a dull red orb, hanging ominously in a nearly completely black sky. The wind is howling, the sun motionless in the velvety sky. If you try to wait for sunset, it will never come; you are locked into an eternal day.

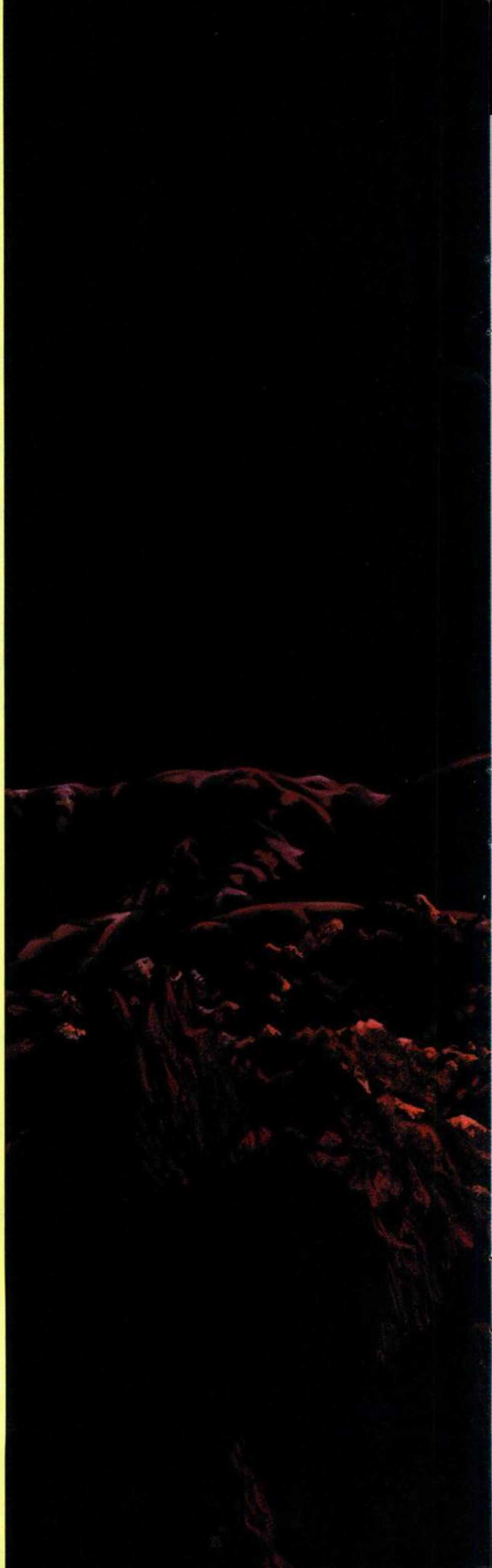
More than 90 percent of the stars in our galaxy are red dwarfs. These low-mass stars use their fuel so slowly that they can barely get hot, glowing feebly with half the surface temperature of the Sun or less. A typical red dwarf has only one-tenth the mass and two-tenths the radius of the Sun, and shines at an incredibly weak 0.00006 times the Sun's luminosity.

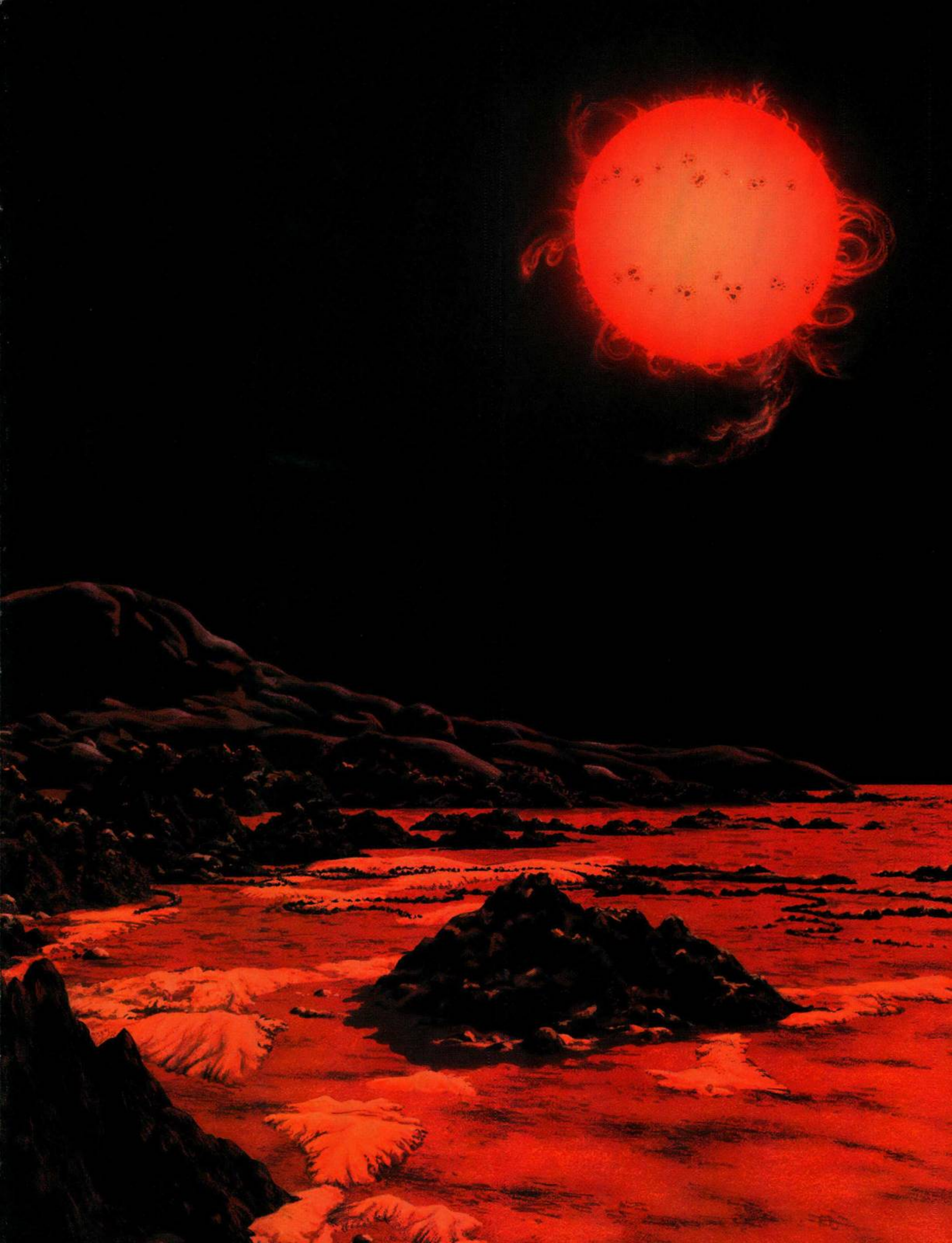
What can we expect from a planet orbiting such a star? For one thing, it must huddle closer to its star to receive as much warmth as we enjoy here. To give the planet a more earthlike temperature, we'd have to drop it to just 6 million kilometers from the star's surface, or about one-tenth the distance of Mercury from the Sun. From this distance even the tiny red dwarf would look about five times bigger than the Sun in our sky. Surface features like starspots (the stellar analogue of sunspots) would be obvious to the naked eye. The star would be about 1/30 the total brightness of the Sun, but would glow red, like a vast, eerie ember hanging over the planet.

The red dwarf's gravity may be weak, but from such a small distance its effects would be felt. The gravity could cause the planet to be tidally locked with the star, meaning its rotation ("day") and revolution ("year") would be equal in length — from that distance, a little more than nine Earth days. The Moon is tidally locked with Earth, which is why it always shows the same face to us. To someone standing on the tidally locked planet's nearside, the star would never seem to rise or set; it would always hang motionless in the sky. That side of the planet would be very hot, and the farside very cold.

The rotation of the planet would be slow, but enough to generate circulation patterns in the air. The air on the planet directly under the star would heat up and flow away. It would eventually reach the planet's farside, where it would cool before flowing back to the nearside. The result would be a steady, constant wind. Even with this wind distributing the temperature, the nearside may still be uncomfortably hot, the farside too cold. The best place to live may be in the higher latitudes, between the two extremes.

From that location, the star would always be halfway up the sky. Since the star emits negligible blue light, the sky would always be black, because there is too little blue, yellow or orange light to visibly scatter. Stars would be dimly visible even during the day. And the wind would always be howling with maddening constancy from the point underneath the star to parts unknown on the dark farside of the planet — proof that alien skies may not be as inviting as our own.





On a planet circling a sunlike star near the center of a globular cluster, the sun is a bright, dancing orange, the sky a deepening shade of red. As you watch, the sun slowly sets to the west, gradually turning fiery red. The sky rapidly changes to black, and stars appear immediately. After a few minutes, the sky seethes with hundreds of thousands of stars, crammed together like angry bees in a jar. From jewels with laser-like intensity to faint red specks barely visible to the unaided eye, there is hardly a place in the sky that isn't pierced by the light of a star.

Globular clusters (or "globulars") are the smaller cousins of galaxies. A typical globular may be under 100 light-years in diameter, with the highest density of stars in the core. Hundreds of them orbit in the Milky Way, and some larger galaxies have thousands.

While even a small galaxy may have billions of stars, globulars have only a few million. But the stars in a globular are much more tightly packed than they are in our neck of the galactic woods. Near the Sun, stars are on average about four light-years apart (in fact, the nearest known star is 4.2 light-years away). In the core of a globular, however, stars are a mere 0.06 light-years apart, only 50 or so times the diameter of our own solar system.

Globulars can be well over ten billion years old, so old that all the highest mass stars have long since died. A star's lifespan depends on its mass, with high-mass stars burning up their fuel faster than more tightfisted, low-mass stars. However, stars at the upper mass limit are in trouble. When a star uses up its fuel, the core heats up tremendously. It dumps that extra heat into the outer envelope of the star, which swells like a hot air balloon. The amount of energy radiating from the bloated star goes way up, increasing its brightness by hundreds or thousands of times. Ironically, though, the increase in area means the heat gets spread out more, so the surface actually cools down, turning the star red.

Over thousands of years, a red giant actually ejects its own atmosphere as a super-solar wind, leaving the hot core exposed to space. Depending on the rate of the wind, the core can be either red (like Arcturus) or a brilliant blue.

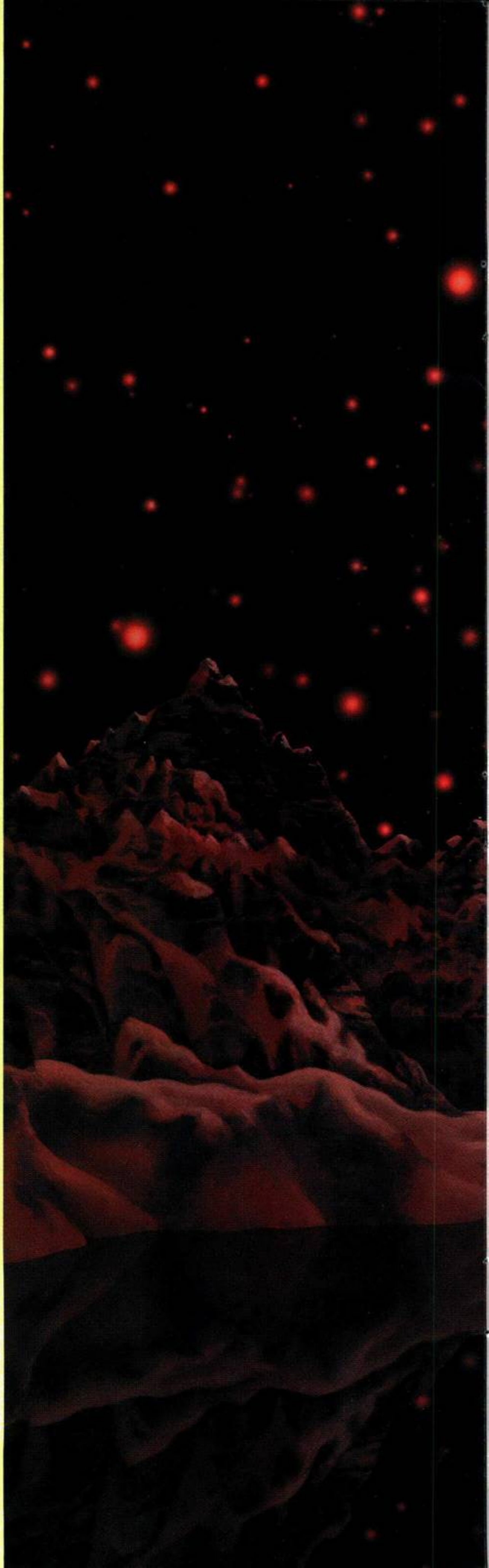
Imagine standing on a planet a few light-years from the core. For a star to have a viable planet, it must be below the mass limit for the formation of a red giant. It would be a reddish-orange star, a bit smaller and cooler than the Sun. If the planet is earthlike, the sky won't be blue, because the star won't produce enough blue light. Instead, the sky might be orange or faintly red even at noon. The sky would quickly become black after sunset, allowing the glory of the cluster to emerge.

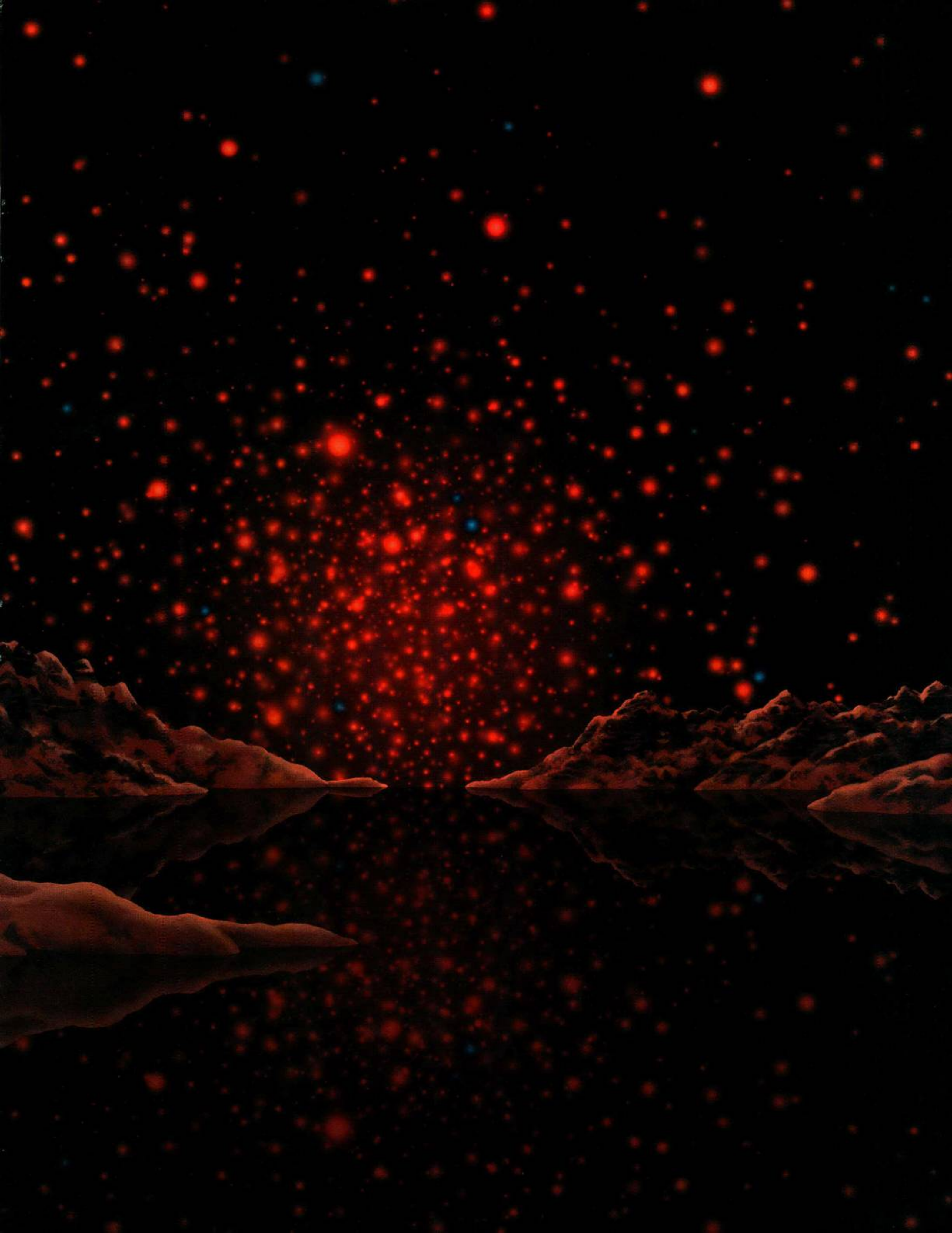
The vast majority of stars you see would be the relatively faint, low-mass orange and red stars, so dim that they will fade to invisibility if they are even a few light-years away. You probably wouldn't notice them anyway, for scattered throughout the sky would be hundreds or perhaps *thousands* of brilliant stars, flaming jewels at or just past the current mass limit of the cluster. They would cast a visible shadow and be seen easily during the daytime. The majority of these stars would be clustered noticeably near the core. Most would be ruby red, punctuated by blue sapphires. One of the dying stars might be close enough that it would actually be resolvable as a disk. But the most awesome sight would be the core rising over the horizon, which might remind you of flaming bees in a cloud surrounding their hive, frozen in time.

Yet, such a world may not form at all. Stars in globulars tend to have low amounts of heavier elements like iron and nickel, meaning earthlike planets could not form around them. Close encounters with nearby stars in the high-density environment may suppress planet formation, or worse, eject newly formed planets from their birth star.

As fantastic as the view might be from a planet inside a globular, such a planet may only exist in our imaginations. ■

Philip Plait is an astronomer at Sonoma State University in California. His first book, Bad Astronomy *(Wiley and Sons), was published in March 2002. He acknowledges the help of Jeff Hester and Wayne Landsman in writing this article. Visit Phil's website at http://www.badastronomy.com.*





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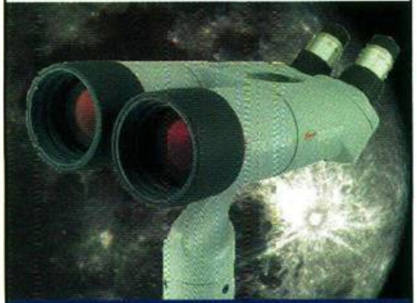

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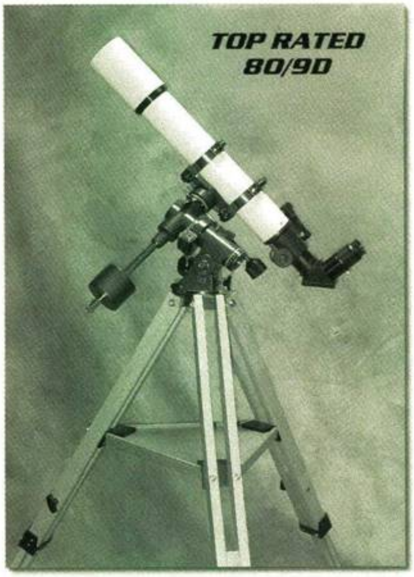

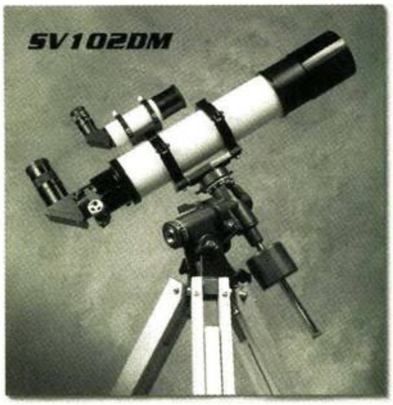

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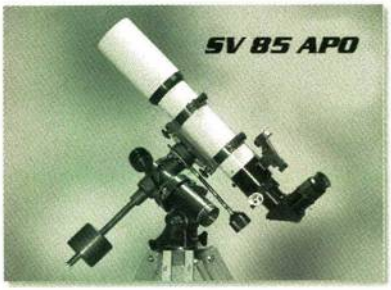

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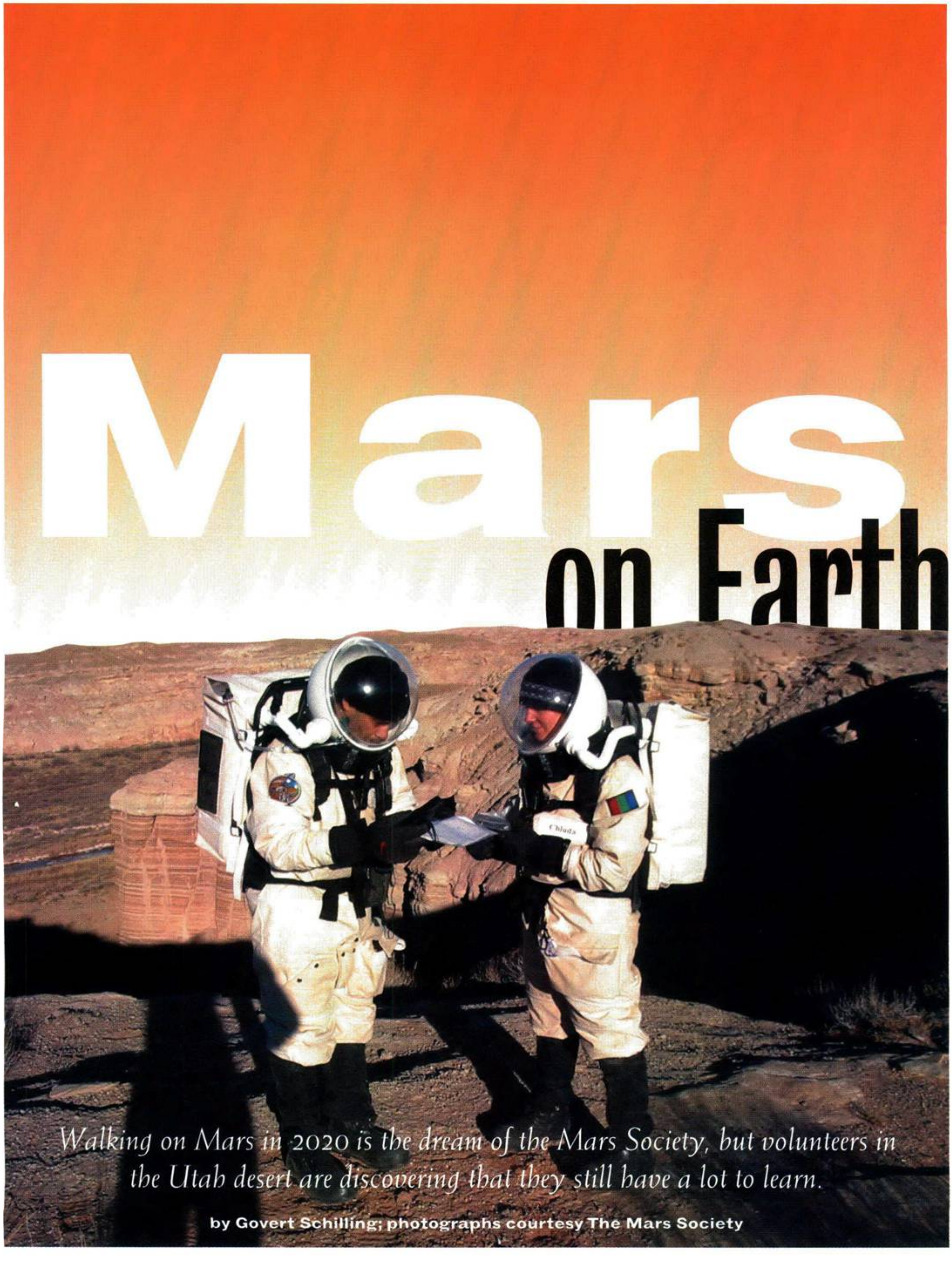


Walking on Mars in 2020 is the dream of the Mars Society, but volunteers in the Utah desert are discovering that they still have a lot to learn.

by Govert Schilling; photographs courtesy The Mars Society

Through the scratched glass of my space helmet, I look around. A barren rock desert stretches as far as I can see. Wisps of red sand blow in the wind. Rolling hills and bizarre rock formations dot the horizon. Stones and pebbles crunch beneath the wheels of my all-terrain vehicle.

I am on "Mars."

The four-wheeled Kawasaki has no problem with ditches, pits, and stones, but the bumping makes the straps of my backpack cut into my shoulders. My left boot has been tied too tight. The little hose for sipping water pricks my chin. I'm sweating like a pig.

I ignore the bright blue patches of sky, the dark thunderclouds, and the fact that I'm 2.5 times too heavy for Mars. Inside my spacesuit, no one can hear me shout; my radio is turned off.

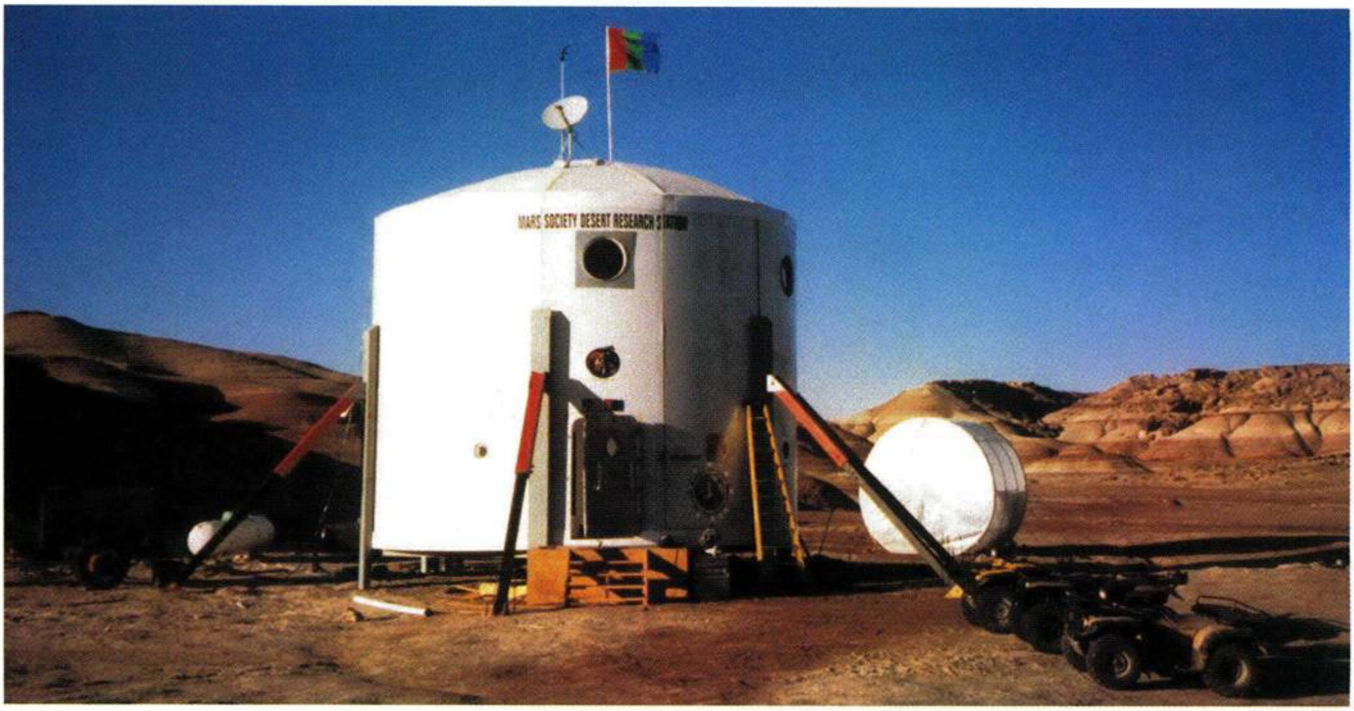
Mars isn't as far away as you might think. Drive to Hanksville, Utah, west of Canyonlands National Park. Turn east on Highway 24 at Blondie's Eatery. Then take a right on a dirt road into the desert between mileposts 13 and 14. After 2.5 miles, the Mars Desert Research Station appears on your left.

Three men and three women live and work here in a mockup Mars lander. Idealists, dreamers. Someday, people will really go to Mars. Maybe someday soon, if only NASA would listen to the visionary plans of Robert Zubrin, inventor, writer, and founder of the Mars Society. Here, in this oversized tin can, volunteers are gaining the much-needed first experience — a full simulation.

Zubrin is the founder and director of Pioneer Astronautics in Lakewood, Colorado, where new space technologies are being developed. There, they will turn laughing gas into oxygen, so astronauts can make longer spacewalks. They'll produce rocket fuel from hydrogen and oxygen that exists in the atmosphere and soil of Mars. They'll develop new propul-

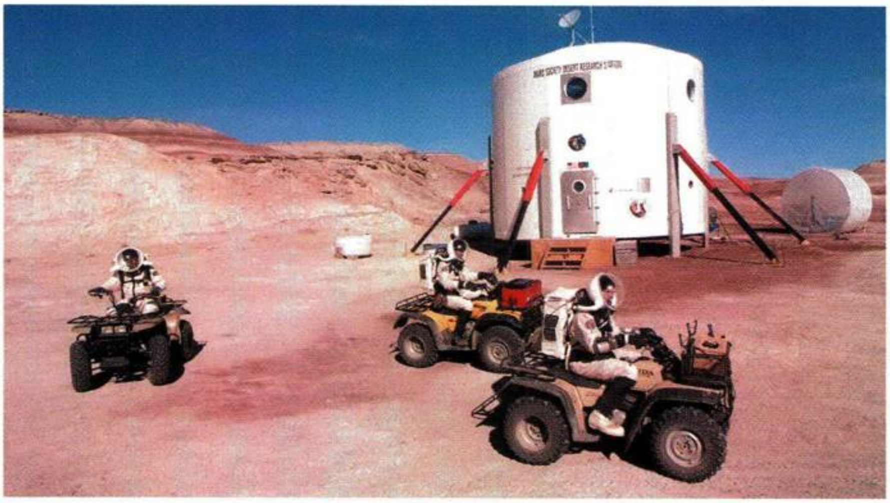
◀ Mars visionaries Robert Zubrin (left) and Heather Chluda contemplate the exploration of the Red Planet while pinpointing their position in the Utah desert.

▶ The crew makes final preparations before entering the airlock, the final stop before stepping out onto the "martian" surface.



▲▲ The Mars Desert Research Station in Utah — which is based on elaborate NASA construction drawings — flies the red, green, and blue Mars flag.

▲ Whenever crew members venture out on geological expeditions, they don their spacesuits and try, as much as possible, to keep to a strict schedule.



▲ Space-suited "Marstronauts" hop on ATVs as they depart the Mars Desert Research Station for a simulated EVA.

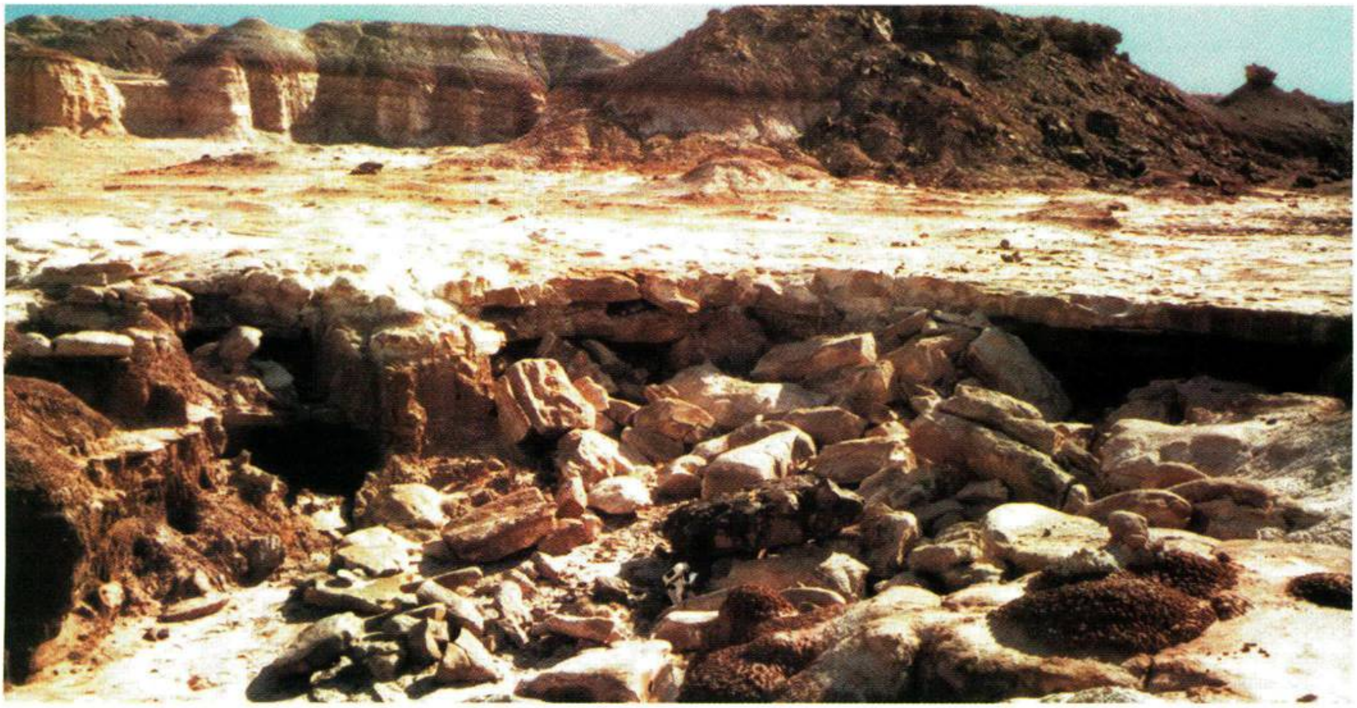
sion techniques, inflatable space structures, and balloons that can function in the rarefied air of Mars.

Six years ago, Zubrin wrote *The Case for Mars: The Plan to Settle the Red Planet and Why We Must*. The book is an eloquent plea for a fast manned mission to Mars. Not in the expensive NASA way — lugging large quantities of fuel with you for the flight back home — but using the cheap Zubrin method: First launch an unmanned spacecraft that produces fuel on Mars, and then send humans to the Red Planet. In 1998, he founded the Mars Society, a private association with members all over the world. Using donations, contributions, and corporate sponsorships, he hopes to realize his dream.

The simulated Mars base is a start. Never before has an experiment like this been carried out. How do crew members respond, what problems do they encounter, how much water is needed each day, are the tiny cubicles big enough? For two weeks, Zubrin himself was part of the crew. Of course, I am welcome to visit. The more publicity, the better.

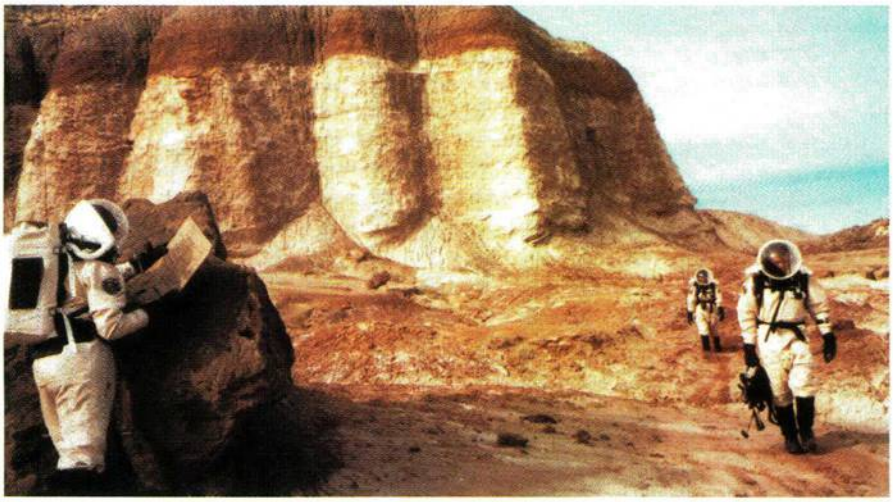
NASA is intently following the project. It does not have any serious plans for a manned Mars trip, but many ideas are floating around, and thick reports with construction drawings of Mars bases and extensive daily schedules exist. The Mars Desert Research Station is based on those drawings, and the volunteers keep to that schedule as much as possible — including on geological expeditions. All dressed up in spacesuits, of course.

A rental car takes me from Earth to Mars — a long drive through a surrealistic landscape that increasingly resembles the Red Planet. The white Mars habitat, partly hidden behind a hill, fits naturally in the desolate scenery. This seems like a scene from a science-fiction movie — the living facility has four large legs, small portholes on the upper level, and a step leading to the air lock. To the left stand three all-terrain vehicles used for field trips. In the back is a small greenhouse with a few withering plants. And proudly flying in the wind: the red-green-blue colors of the Mars flag. The colors, proposed by planetary scientist Pascal Lee, represent the transformation of Mars from barrenness to life depicted



▲▲ A lone explorer investigates a field strewn with giant boulders. Learning to negotiate such a tricky landscape will prove invaluable to future Mars astronauts.

▲ With as much land area as Earth, Mars offers a lot of territory to cover. Astronauts will need some sort of transportation to see more than a minuscule part of the Red Planet.



▲ While one astronaut checks out the planned schedule, two others trudge wearily under the hot Utah sun.

in Kim Stanley Robinson's trilogy, *Red Mars*, *Green Mars*, and *Blue Mars*.

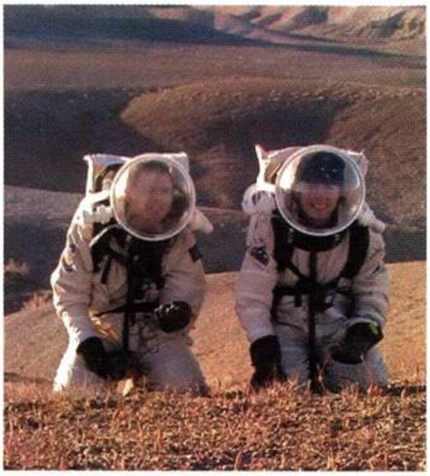
I can hear voices and laughter inside, but no one answers my knocking, shouting, and honking. Only after some 15 minutes, Sam Burbank pokes his head outside. Visiting the hab? Impossible — that would disturb the psychology experiment. Arranged with Zubrin? That may be so, but today's a bad time. Sam understands my disappointment. He is a journalist himself, for *National Geographic* and other publications. Can I come back in the afternoon? If so, I can take part in an EVA, an extra-vehicular activity.

What Sam doesn't tell me is that the chemical toilet and the water pump have broken down, and that he has been mopping and cleaning all morning. How much time does a crew need just to keep the base running? A severe storm in March nearly dislocated the door; it is now kept in place by a wooden wedge. Experience is gained, even if it's just repairs and maintenance.

In the late 1970s, Sam Burbank (now 34 years old) wallpapered his bedroom with pictures of Mars taken by the unmanned Viking landers. Robinson's trilogy rekindled his interest in the Red Planet. Robert Zubrin's founding of a real Mars Society in 1998 almost seemed too good to be true.

Together with commander Frank Schubert, a 47-year-old architect and composer ("Seriously, I am a very distant relative of Franz"), Sam carries out a unique music project: through e-mail, the Mars crew is in touch with a number of musicians all over the world, including Elton John. The goal: to write a pop song together — music as a bridge between planets. "If you're on Mars for 18 months, you need some sort of recreation," says Frank. "Nothing works as good as music."

Not that it's easy, with a broken knee, a broken wrist, bruised vertebrae, and a concussion. In late March, Frank's single-engine private plane crashed a few miles from the Mars base. No reason to stay home, he decided. "I recover fast." Moreover, it's "his" base: He designed the interior and constructed the habitat at its current location. But two legs are missing because the subcontractor didn't



▲ **A pair of astronauts examines a field of fossil oysters. All the volunteers hope humans will discover and study fossil life on Mars.**

▲ **Sticking to a tight schedule is all a part of simulating what a real mission to Mars would be like.**

meet his obligations, and the supplier somehow ended up in jail. "That's the risk when you want to do everything low-budget."

When I return in the afternoon, Steve McDaniel helps me with my spacesuit in the special dressing room at the lower level of the base. A thick, stiff overall with a zipper on the back, and pockets, buttons, and Velcro everywhere. The backpack does not contain oxygen flasks, but instead has a water bag and electrical fans to blow cool air through the helmet. Using duct tape, Steve attaches the earplug of my radio to my right ear; he connects the water, and after boots and gloves, I finally receive the helmet. I am alone with the sound of my breath.

Steve's colleague Penny Boston is already waiting in the airlock. Twenty minutes of decompression is what the human body needs to get used to the low air pressure on Mars. Although the air pressure in Utah is a normal 1,000 millibars or so, the waiting time is part of the game. Full sim. Steve is as serious as any real astronaut. When he wants to test the radio link with the other crew members, he doesn't say, "Hi Kelly, I just wanted to check this radio." Instead, he utters "Capcom. Capcom. This is EVA Room. EVA Room. Do you read me? Over." Sometimes you read about adults who spend their free time replaying battles of the Civil War, with costumes and all. Is the Mars Desert Research Station also a hobby that has taken on a life of its own?

But once we're on our way, all doubts disappear. I am traveling cross country on the Red Planet. Steve drives some twenty meters in front of me; Penny is behind me. Three lonely astronauts on another world. The desert is big and empty; there are no tourists here. Is this Mars? With some imagination, yes. Just a little bit. "Capcom. Capcom. EVA team. EVA team. We're heading for Lith Canyon. Over and out."

Steve McDaniel is a 50-year-old Texas businessman. He made his money with technology patents and lawsuits, and with biotechnological ways of fighting nerve gas. He's been hooked on Mars ever since he read Ray Bradbury's *The Martian Chronicles.* Steve invested a lot of money in the Mars Desert Research Station, where he is not only the health and safety officer but also the space janitor and a flute and banjo player in the music project.

Last winter, just like Frank Schubert, Steve was part of the first crew rotation in Utah. He knows the beating of the drum. He helps Penny don her spacesuit, explains the controls on the ATVs, and knows the way to Lith Canyon, a few miles north of the base. The Mars crew named this small canyon after the many lithophytes (microorganisms that live on rocks) found there.

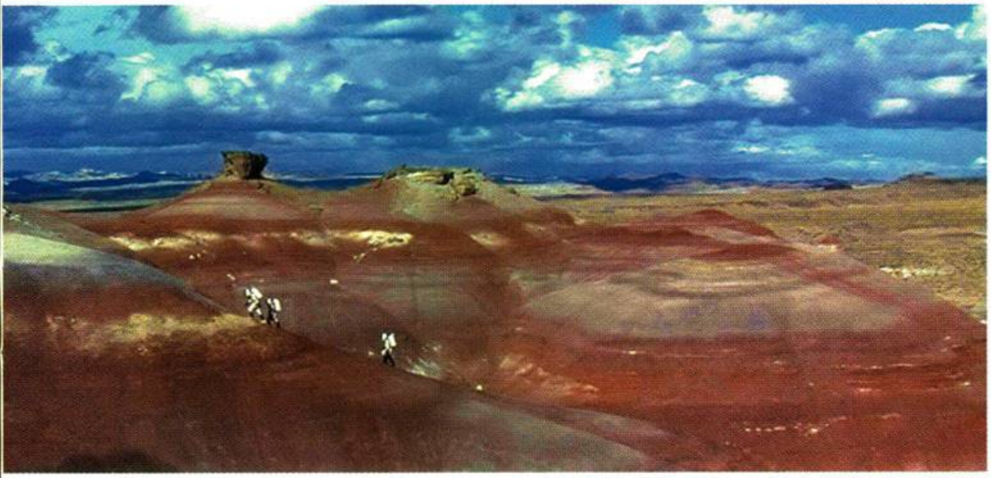
At the edge of the canyon, we leave the four-wheeled motorcycles behind. Minutes later, we carefully clamber down, sweating and panting. Penny would stop at every rock she comes across if she could. Dr. Boston, as Steve consistently calls her, is a renowned biologist at the University of New Mexico in Albuquerque and a world authority on extremophiles — organisms that live in extreme environments like hot water springs and poisonous caves. Small dark spots, minuscule holes in the rock surface — everything points to biological activity.

Penny, 46, was one of the founding members of the Mars Society. She hopes microorganisms will be discovered on Mars, or at least their fossil remnants. "Here, we gain experience in recognizing interesting rock samples," she says, "structures at the surface that possibly point to biological activity deeper down." No easy task in an outfit that makes it hard to kneel or squat, and with gloves as large as coal shovels.

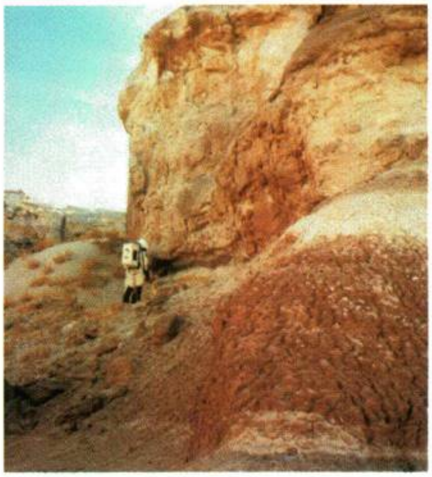
Penny Boston is not the only crew member with a scientific background. Thirty-two-year-old psychologist Ephimia (Ephi) Morphew works at NASA's Johnson Space Center in Houston, where she coordinates the psychological studies

Living in a Polar Desert

The Mars Desert Research Station in Utah is not the first simulation project of the Mars Society. A few years ago, on Devon Island in the far north of Canada, the Mars Arctic Research Station (right) was constructed and occupied for a few months by rotating crews. And in the spring of 2002, the construction of a European Mars habitat was completed, again under Frank Schubert's leadership. The completed hab will almost certainly be erected in Iceland. Although all habs have more or less the same structure and layout, according to Schubert, the European hab is a Taj Mahal compared with the more primitive version on Devon Island and in Utah. — *G. S.*



▲ **The reddish soil of Utah serves as a surrogate for the rusty surface of Mars. Here three astronauts climb a ridge called Petrified Wood.**



▲ **An astronaut prepares to sample an intriguing rock face. Returning such samples from Mars is high on NASA's list of priorities.**

of astronauts who fly to the International Space Station. And Kelly Snook (also 32 years old) is a planetary scientist at NASA's Ames Research Center in Mountain View, California.

Does this imply that NASA supports the Mars Society's simulation project? Officially, there's no involvement according to the two youngest crew members. But the space agency is unquestionably interested in the results of the first full simulation. The lack of financial support from NASA stems largely from a personal disagreement between Robert Zubrin and former NASA administrator Daniel Goldin.

Differences in style, that's what it's all about. Kelly has been closely involved in NASA's Haughton Mars Project on Devon Island, in the far north of Canada. The first Mars Society base was constructed at the same location, but the planned cooperation came to a quick end when the Society sold exclusive film rights to the Discovery Channel and also seemed to be less concerned about safety.

In Utah, safety also proves to be an important issue. On the way back from Lith Canyon, Steve and I stop our vehicles just behind a sharp curve around a hill to see if Penny is still behind us. A moment later, she appears from behind the hill but coming too fast. She loses control, unable to take the sharp turn, and the ATV lands on top of her. As fast as we can, we run toward her.

"We need to break sim," says Steve. He takes off his gloves and removes Penny's space helmet. Together we put the ATV back on its wheels; it won't start anymore. Penny is lucky enough to have just a few large bruises. "Those gloves are much too large," she says. "I didn't have any grip on the brakes." At this distance, there is no radio link with the base, a few miles farther down and behind the hills. Using a towline, we pull Penny's ATV behind us. On Mars, an accident like this could prove fatal.

Once back in the EVA Room, I take off my spacesuit. Finally a little more freedom of movement. I talk about our trip with Penny and Frank. Steve disappears to the upper level to discuss something with the other crew members. Minutes later he is back. Maybe I would like to join the crew for dinner and take a look around in the base after all? Later, in an e-mail message, he writes: "I especially appreciate your helping me and Dr. Boston safely return to the hab after the minor ATV accident." One good turn deserves another.

The upper level of the base consists of a large common room with work benches along the cylindrical wall and a long table in the center. One corner has been transformed into a provisional sound studio; on the other side is a small kitchen. Six tiny cubicles, just large enough for a bed, are the only private areas. There are laptop computers all over the place (the base is connected to "Mission Support" on "Earth" by e-mail through a satellite link). Mars posters grace the walls, and there's even a small library with lots of science fiction.

Sam has gone. "Extended EVA," jokes Kelly. He is trying to find a new water pump. But in this case, he uses a car. Later I am told that he returned the following day, after 14 hours of driving to Grand Junction and back. "You can make fun of it," says Frank when I point out that there are no water pumps for sale on Mars, "but if you want to do simulations, you have to start somewhere. At least we are starting somewhere."

Ephi has prepared the five Marstronauts and their earthly visitor a delicious meal: polenta with mushroom sauce, pan-fried sweet potatoes, and kale, carrot, and currant salad. "We've decided to have macrobiotic meals every day," says Steve, who concedes that he is certainly not a vegetarian. "We got all ingredients and recipes from a wholesale trade company in macrobiotic food. So far, it's OK."

Before I leave — Kelly is mailing the daily report to Mission Support in San Francisco, Frank is plucking the strings of his guitar, Steve and Penny are discussing the accident — I take part in Ephi's psychological survey: a long questionnaire that has to be completed by the other crew members every few days. As the Sun sets and the desert cools down, it's warm and cozy inside. There are worse things in life than being part of a six-person Mars crew.

It's now 9:30 P.M. Outside it's pitch dark; I can hardly find the dirt road that takes me back to Hanksville. The night sky on Mars is almost indistinguishable from the one on Earth; the illusion is spoiled only by the nearly full Moon. On the rocks, the portholes of the hab throw round splotches of light like surrogate moons. Every now and then I see a shadow pass behind one of the windows; sometimes I can hear soft laughter. Then, the Mars Desert Research Station disappears behind a dark hill. I am alone in an alien landscape. ■

Dutch writer Govert Schilling is the author of more than twenty books on astronomy. His most recent article for Astronomy *was "Europe's Science Machine," in the August 2000 issue.*

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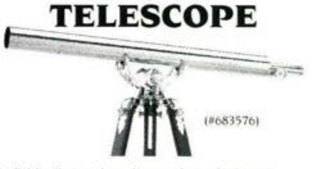

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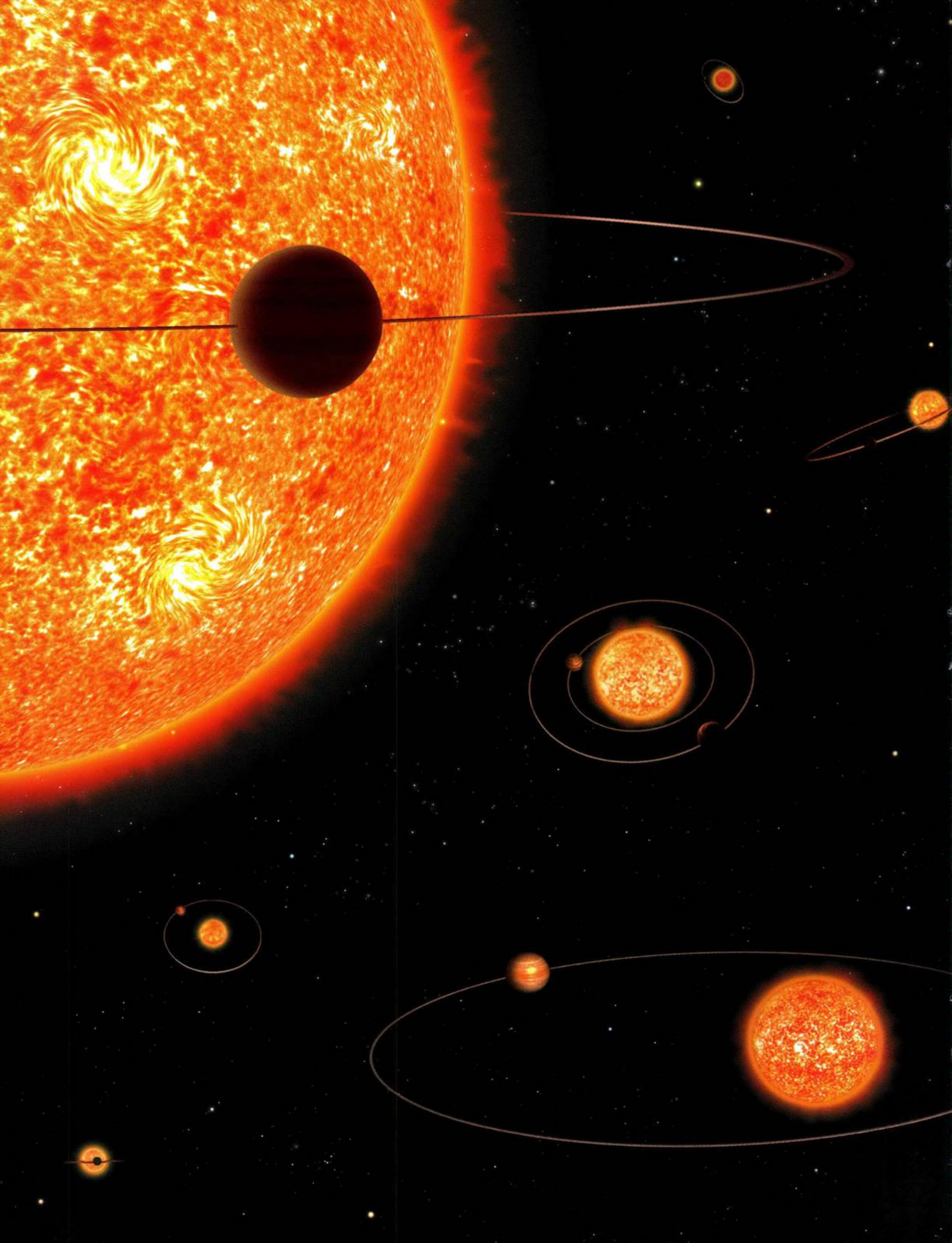

Join the Hunt

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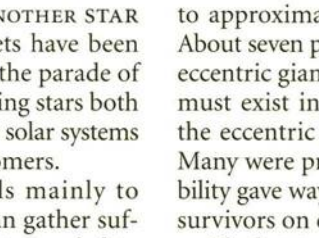
A new observing program, based on commercial CCD cameras and modest-size telescopes, lets backyard astronomers help search for extrasolar planets.

by Greg Laughlin and Tim Castellano

SINCE 1991 WHEN THE FIRST PLANET ORBITING ANOTHER STAR was discovered, more than 100 extrasolar planets have been found. First in a trickle, then in a steady stream, the parade of "exoplanets" has grown to encompass those orbiting stars both ordinary and exotic. This growing portrait of alien solar systems has generated a lot of excitement among astronomers.

The job of discovering these systems falls mainly to researchers working with large telescopes that can gather sufficient light to permit the delicate measurements needed to detect an exoplanet's tiny signal. But recently, a new technique has emerged that will let backyard astronomers equipped with CCD cameras help survey candidate stars — and, with luck, actually detect a new planet.

To understand better what we're hunting for, let's first survey the variety of exoplanets.



As a general guide for observers who want to help hunt for extrasolar planets, we have assembled an equipment "Dream Team." Running about $7,500, it includes a telescope, a CCD, a laptop, and software. Tim Castellano

The Exoplanet Species

As the roster of newly-discovered worlds grows, astronomers are finding that all planets — exo- and otherwise — divide naturally into four basic classes. Perhaps the most exotic category contains the so-called "hot Jupiters." The prototype orbits 51 Pegasi and in 1995 became the first extrasolar planet to be discovered around a sunlike star. Hot Jupiters are distinguished by extremely short orbital periods, which range from three days to roughly a week. (By contrast, Mercury's 88-day period seems downright leisurely.)

A typical hot Jupiter orbits its star at roughly ¹⁄₂₀ the distance Earth is from the Sun. (That's about eight times closer than Mercury goes.) As a result, these objects glow at the temperature of red-hot coals, about 2,200° F. Their small orbits lead to large tides, which keep one hemisphere facing the parent star. Tides also cause their orbits to be nearly perfect circles. Hot Jupiters have typical masses resembling that of Jupiter itself. In all, about one percent of the sunlike stars in our local galactic neighborhood seem to be accompanied by a hot Jupiter.

A second and very numerous category of planets might be labeled the "eccentric giants." The 90-odd known members of this class tend to be quite massive (averaging several Jupiter masses). Their orbits have periods ranging from roughly 10 days to approximately 1,000 days, and are often highly elliptical. About seven percent of sunlike stars seem to be accompanied by eccentric giants, meaning that literally billions of these planets must exist in the Milky Way alone. The elongated orbits of the eccentric giants hint at catastrophic events in their past. Many were probably born in environments where orbital stability gave way to planetary collisions and ejections that left the survivors on disturbed, highly eccentric orbits.

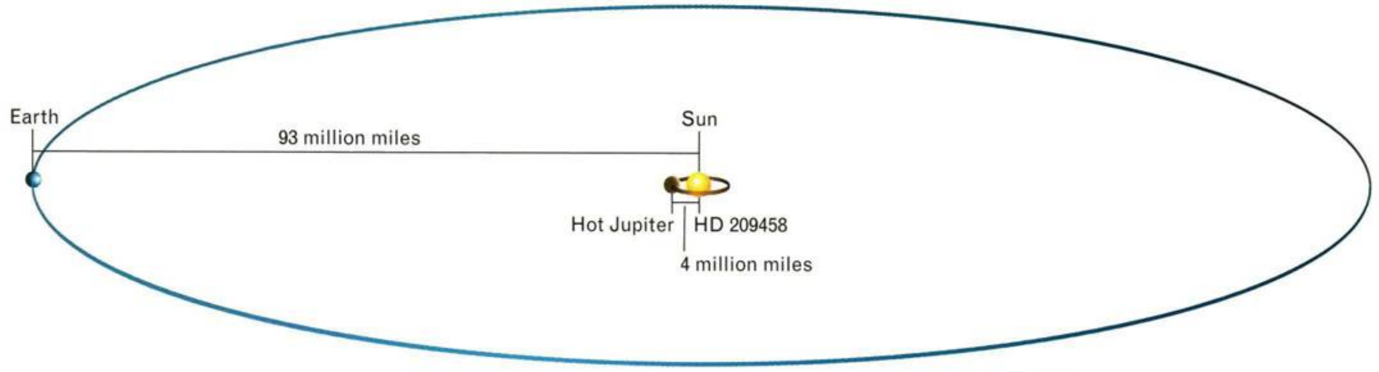
The last two categories of planets are familiar to us from our own solar system. These include ordinary gas-giant planets such as Jupiter and Saturn, which have long-period, nearly circular orbits. The two companions to 47 Ursae Majoris and the outermost planet orbiting 55 Cancri also appear to fall in this class.

Finally, the fourth group consists of small-mass, rocky bodies, which include the Sun's terrestrial planets — Mercury, Venus, Earth, and Mars — and the three inner planets orbiting the pulsar PSR 1257+12.

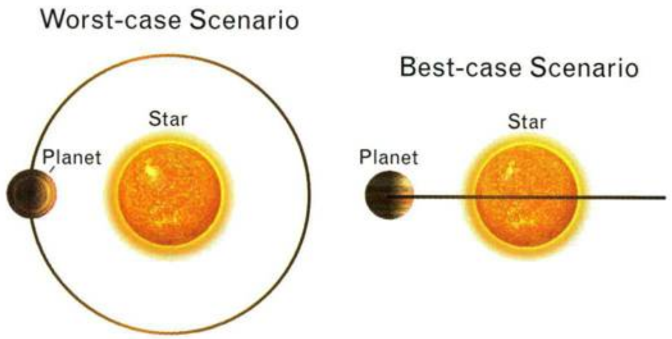
Detecting Exoplanets

All of the known hot Jupiters and eccentric giants have been discovered using the Doppler velocity technique. As a planet orbits a star it gives the star a minute wobble. The part of the wobble that lies in our line of sight causes a Doppler shift in spectral lines that astronomers can detect. (When there is more than one planet, the wobble becomes complex but the principle doesn't change.)

The Doppler method can produce a very accurate picture of a planetary orbit, but it has a serious shortcoming. It can determine only a minimum mass for any particular planet, rather than the planet's actual mass. This is because an observed periodic wobble can be produced by a variety of circumstances that lie between two extreme cases. In the first extreme case, a planet has an orbit lying in our line of sight to the star — the mass detected is then the planet's true mass. The other case is when a planet follows an orbit that happens to be oriented almost face-on. The detected wobble is only a small fraction of the actual wobble, and the planet's real mass is much greater than what's detected. Until astronomers can tell how a system is



Earth and HD 209458's orbits shown to scale



Above: The star HD 209458 hosts a "hot Jupiter" that whips around it in a tight orbit that lasts just 3.5 days. *Astronomy*: Roen Kelly, with thanks to Z. Levay (STScI) **Left: Most extrasolar planets have been found using the radial velocity, or Doppler, method, which shows a shift in the star's spectrum due to the planet's gravity. The Doppler effect only measures wobbles along the observer's line of sight (through the paper in the diagrams at left), so in the worst-case scenario, we see the planet nearly from above, where this motion is very small. This face-on orientation produces only an estimate of the planet's *minimum* mass. If we see the orbit edge-on, the star will be pulled back and forth along our line of sight, providing an accurate mass.**

Astronomy: Roen Kelly

oriented, this ambiguity can't be resolved and exoplanet masses remain uncertain.

There is, however, a way to remove the ambiguity. If the plane of a particular planet's orbit happens to lie close enough to our line of sight, then once per orbit the planet will pass directly in front of its parent star as seen from Earth. The resulting eclipse, or transit, blocks part of the star's light. Thus a dip in brightness would confirm that the orbit is being viewed edge-on, and astronomers could determine the true mass of the planet. Furthermore, by measuring the amount of the star's light that is blocked, astronomers can work out the actual physical size and density of the planet. Careful study of the stellar light curve during the transit can even show if the planet is accompanied by rings or moons.

The probability of observing a transit is greatest for planets that lie close to their parent stars. The chance that a hot Jupiter on a three-day orbit will show transits is about 10 percent, whereas a planet with a period of two weeks has roughly a 4-percent chance of transiting. For planets with longer periods, the chances dwindle drastically. To produce a transit with an extrasolar planet in a 365-day earthlike period, the planet's orbit must lie within 0.3° of edge-on; the chance of this happening is roughly 0.5 percent.

As of now, transits of only one extrasolar planet — the companion to star HD 209458 — have been detected and confirmed. The host star is much like the Sun and lies 154 light-years away in Pegasus. Not surprisingly, given the odds mentioned above, the planet, named HD 209458b, falls in the hot Jupiter category, with a 3.525-day orbital period. Its mass is 70 percent that of Jupiter, and during its three-hour transits, it blocks about 1.7 percent of its 7.65-magnitude parent star's light. The planet's radius is 35 percent larger than Jupiter's, indicating it is significantly bloated, perhaps as a result of its blisteringly hot location. New computer simulations of HD 209458b also suggest tidal effects may cause complicated atmospheric flows that may be observable in its spectral signature.

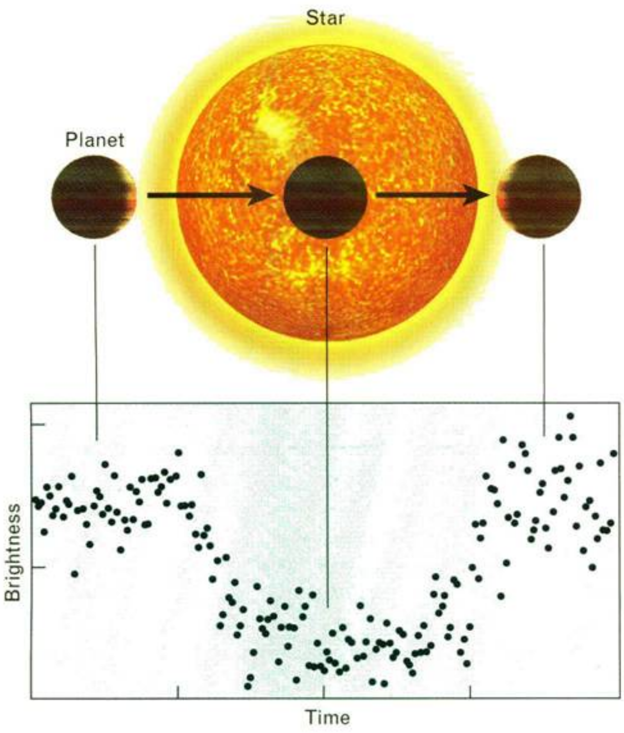
Astronomers discovered HD 209458b in 1999 with the Doppler technique. They monitored its light closely in hopes of detecting planetary transits, which were indeed discovered almost simultaneously by two groups of professional observers. Over the years since, several amateur astronomers using 8- to 14-inch telescopes, commercial-grade CCD detectors, and standard telescope-control software have detected the HD 209458b transits. They have measured the brightness of the star many times as the planet passes into eclipse (ingress) and out of eclipse (egress). The amateurs compare the brightness of HD 209458 with that of several nearby stars that remain constant in brightness during the transit. This technique, called differential photometry, acts as a truth-check. It lets observers be reasonably confident that an observed dimming or brightening of a star is due to the planet — and not to changes in cloud cover or the star's altitude above the horizon.

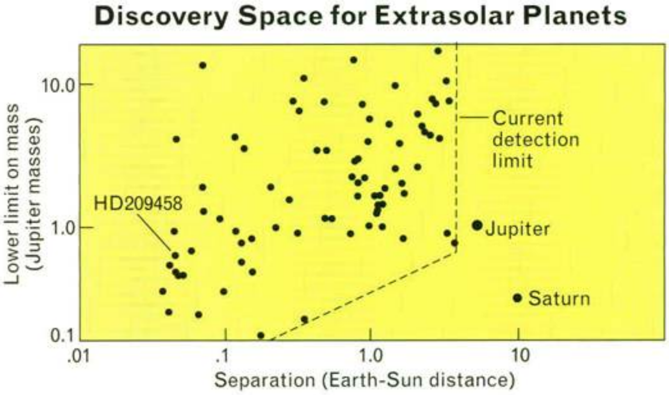
The Transitsearch.org Collaboration

The success of these observations raises a provocative question: Could a group of experienced and committed amateur astronomers discover new transiting exoplanet systems?

We created www.transitsearch.org because we think the answer is yes. The Transitsearch strategy harnesses a worldwide network of telescopes to take simultaneous measurements of planet-bearing stars during times when a transit might occur. If several independent observers simultaneously measure a dimming or brightening of the star at the predicted times, then the evidence is strong that the star has a planet in transit. Confirmation would follow at the next predicted transit.

When astronomers discover a new hot Jupiter using the Doppler method, the news is sent to several professional observatories. They make photometric measurements of the star during predicted eclipse windows to see if a transit is occurring. However, when an eccentric giant with a period longer than a week is discovered, there's currently no systematic follow-up program to detect transits. As the planetary period increases, the





Above: Most extrasolar planets found to date are at least as large as Jupiter and lie near their stars. A planet on a three-day orbit has a 10 percent chance of being caught transiting its star, whereas that drops to just four percent for an orbit of two weeks.

Astronomy: Roen Kelly, with thanks to A. Feild (STScI)

Left: In the transit method, the host star's light dims when a planet passes in front of it. As opposed to the Doppler method, astronomers know they are seeing the orbit edge-on, which offers the best estimate of the planet's mass and size. The plot at left is actual data from the transit of HD 209458, which lasted about three hours.

Astronomy: Roen Kelly, with thanks to G. Henry

probability of transit falls off and uncertainty about when a transit should take place increases.

These two effects combine to mean that follow-up observations to check for the transit of a planet with, say, a 30-day period (with a transit probability of two percent) are unlikely. The observations will take a lot of time while offering rather slim chances for success. Faced with this fact, the committees that allot telescope time to observers usually give other observational projects higher priority — and so a window of opportunity opens for a group of persistent and dedicated hobbyists.

When we began collaborating with amateurs, we documented what was needed to make a successful observation of HD 209458b. This process helped map out the difficulties that will greet backyard observers who decide to join the hunt for transits. Indeed, we recommend that new planet seekers first test their observing techniques on either HD 209458 or one of several eclipsing binary stars, whose coordinates and upcoming eclipse times and depths are listed at Transitsearch.org.

Outfitting the Observer

We deliberately chose an observing system using commonly available items. The package costs approximately $7,500. This includes the telescope, CCD camera, software, a laptop, and miscellaneous bits and pieces. The price tag is not small, but it does include items that some observers may own already.

The "Transitsearch.org Observatory" consists of a Meade LX200 8-inch f/10 telescope mounted on an equatorial wedge and the standard tripod. It is fitted with a Santa Barbara Instruments Group ST7E 765x510 pixel CCD camera with antiblooming and an integral autoguider. We placed a focal reducer between the telescope and the CCD to get a 36 by 24 arcminute field of view. We also recommend using a broadband color filter. A filter allows longer exposure times without saturating the CCD and avoids the erratic short-term effects of atmospheric scintillation (twinkling). An ordinary laptop PC running *TheSky* and *CCDSoft* software handles telescope positioning, camera control, and image storage functions. We typically operated our telescope in a suburban yard flanked by two street lights near San Jose, California.

Our particular choice of hardware is by no means the only choice. Any roughly comparable setup should give comparable results. If backyard observers have patience, dedication, and inclination, they can participate in the search for transits.

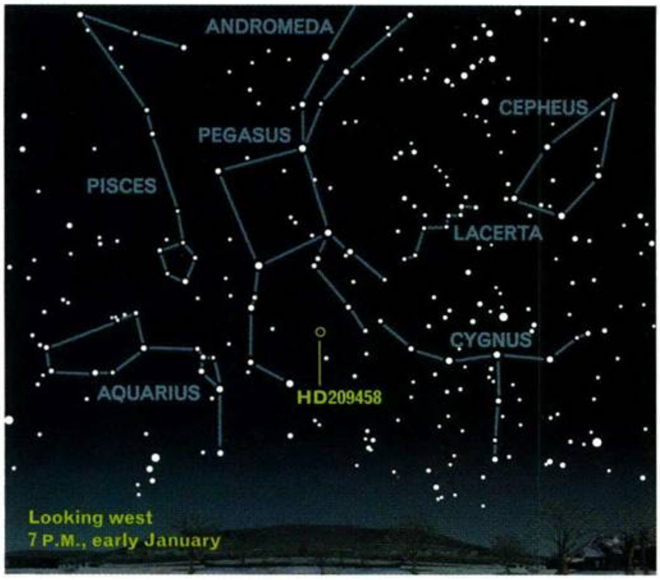
How It Works

The overall objective of a night's observation is to measure the relative change in brightness of the target star during the transit, as compared to other stars in the CCD field of view. For the telescope described above, the field of view is approximately as large as the Full Moon. By measuring the brightness of two or more stars simultaneously in the same CCD images, an observer can correct for changes in the transparency of the atmosphere (due to clouds) or the CCD's response.

With several comparison stars, corrections due to atmospheric extinction (which makes stars appear dimmer as they get lower) and also "color-dependent" extinction (in which red stars are less affected by atmospheric extinction than blue ones) become very small. The technique lets observers follow the difference in brightness between the target star and the comparison stars for many hours during a single night, even though the stars change elevation significantly.

We found that a field of view the size of the Full Moon (half a degree square) generally contains at least one star bright enough to serve as a comparison star. (This means within a magnitude or two of the possible planet-transit star.)

The observer roughly centers the transit candidate star and the comparison star in the field of view. Then a guide star is aligned on the autoguider CCD, and the computer instructs the CCD to take a lot of exposures rapidly. Using many exposures allows the observer to average them to reduce systematic errors and improve the measurement precision. Since each exposure contains close to one megabyte, lots of hard-drive space is



Anyone interested in observing a transit should start with the star HD 209458, around which the only confirmed transit occurs. Above: Face west in the early evening to see the star in Pegasus this month.

Astronomy: Roen Kelly

required to store the several hundred images produced over a night of observing.

We have found the technique can detect changes as small as 0.3 percent in brightness on ordinary nights with occasional light clouds — provided great care is taken while observing and processing the data.

So What About Results?

Transitsearch.org is best suited to find a transiting eccentric giant with an elliptical orbit roughly half the size of Mercury's orbit and an orbital period of several weeks. The temperature on such a planet would be about 440° F.

As soon as backyard astronomers observed a transit, professionals would use the Hubble Space Telescope to confirm it, and the resulting highly accurate light curves would allow determinations of the planet's precise size and density.

This information would give theorists a chance to fill a hole in their knowledge of planetary properties. The hole lies between our own Jupiter, whose outer atmosphere has a temperature of only –240° F, and the bizarre, swollen HD 209458b, broiling at 2,060° F. Furthermore, if an eccentric giant with a longer period is detected, then it's possible it has stable rings or large moons whose presence could be deduced from HST photometry observations.

Estimating the expected number of undiscovered transiting planets in the current census of extrasolar planets is straightforward. For the 14 known planets in the hot Jupiter group, the odds predict slightly more than one transiting case. The present members of the hot Jupiter club have all been carefully examined for possible transits. The efforts led to the discovery of HD 209458b.

We have individually computed the transit probability for each of the eccentric giants. The chances range from a slim 0.2 percent for the companion to Epsilon Eridani all the way up to a startling 15 percent for HD 80606b, which has an extremely eccentric orbit favorably aligned with Earth. Statistically, the number of transiting planets expected to be lurking among the known eccentric giants works out to be 1.07, meaning amateurs' chances of success are excellent provided all of the stars on the list are reliably observed during the predicted transit windows.

Scott Seagroves, an astronomy graduate student at the University of California, Santa Cruz, has written a computer program that estimates how long an observing program must run, and how many telescopes are needed, to give an observational campaign a good chance of success. His simulations show that a single observer, located for example in Kansas City, Missouri, and able to observe every clear night, would require more than 10 years to have a 50 percent chance of discovering a transiting eccentric giant.

That's the bad news. But it may not be as bad as it looks.

Cover Earth

Calculations show that a network of 20 telescopes scattered over the globe is very likely to find a transiting eccentric giant within a year. Having a network covering the northern and southern hemispheres ensures that all planet-bearing stars are visible. Full longitude coverage is also important — observers stationed throughout a wide range of time zones can cover all of a planet-bearing star's transit opportunities, as long as the star is not close to the Sun.

For a well-observed hot Jupiter like 51 Pegasi, predicting transit times is quite straightforward and accurate because its orbit is well determined. If 51 Peg were transiting, we could predict the time of the transits to an accuracy of about 10 minutes. For many of the eccentric giants, however, predicting the windows in which transits will occur is far less precise. If a planet has a small mass, or if its parent star has been observed only a limited number of times, then the Doppler velocity detection technique has difficulty giving an exact description of a planetary orbit. This makes the prediction for a particular planet's transit significantly uncertain.

For multiple-planet systems, the situation can be even more complicated. For example, the two planets orbiting the star GJ 876 exert very strong gravitational influences on each other. Our calculations indicate that if the inner planet (which has a period of 30 days) is transiting, then the next four transits occur at intervals of 30.27, 30.06, 30.39, and 30.15 days.

Transitsearch.org's Role

In setting up the website, we chose a simple mode of operation. Transitsearch.org provides predicted transit times and tutorials on how to get started, plus a discussion forum. At any given time, participating observers can sign on to receive target stars for observation. Observers who choose to do so can post their processed light curves on the site. A website-based discussion group associated with each star will reach a degree of consensus on whether a possible transit ingress or egress was observed. Interesting events will be followed up at the predicted transit times for confirmation. Discoveries made at Transitsearch.org will be attributed to the individual observers and to the network as a whole.

Transitsearch.org offers the experienced backyard astronomer a way to participate in exciting, pathbreaking research. We welcome anyone who is interested — this is your chance to discover new worlds.

Greg Laughlin is an assistant professor of astronomy at the University of California, Santa Cruz. Tim Castellano is an astronomer at NASA's Ames Research Center in Mountain View, California. Visit their website at www.transitsearch.org.

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Gas giants glow and shooting stars streak.

by Martin Ratcliffe and Alister Ling

▶ It's just the beginning of a great season for observing Saturn and Jupiter. Both planets are close to their northernmost points, which for Northern Hemisphere observers means they will climb high up in the sky. This translates to more opportunities to see them in steady air, far above the interfering effects of Earth's lower atmosphere.

Saturn's rings are about as wide open as they can get, giving us a beautiful and awe-inspiring look. Also search carefully for the small flecks of light that are reflected from Saturn's bigger moons. There's only 18 months to go before the Cassini probe swings into saturnian orbit. Check out http://saturn.jpl.nasa.gov for more information.

Saturn is the bright pale-yellow star-like object in the east. Following in Saturn's path, but a couple of hours after sunset, is the much brighter Jupiter. As a newcomer to stargazing, you might wonder how you can tell which of the bright "stars" are planets. The secret is that planets generally don't twinkle like stars. The turbulence in Earth's atmosphere shifts a star's point-like image around a bit, making it fluctuate in brightness and color. Because planets appear as small disks, the shift amounts to just a small percentage of their size.

By mid-evening, the brightest star in the sky, Sirius, flickers a particularly impressive light show in the southeast.

Catch Mercury in the last week of December and first week of January before the speedy planet disappears from the evening sky. It is nicely placed in the southwest at dusk, setting some 75 minutes after the Sun. Start looking about 45 minutes after sunset for a lone star-like point hiding in the twilight.

At midnight EST on January 3/4, Earth reaches perihelion, its closest point to the Sun in its slightly elliptical orbit. Remember that the seasons are caused by the tilt of our planet with respect to the Sun, not by its distance. A couple of weeks ago, Earth's Northern Hemisphere pointed as far away from our heat source as it can. Sunlight spreads out over more territory, resulting in less radiant heat per square foot or meter. The inbound heat cannot counter the outgoing flux, so we chill out. The opposite takes place in the Southern Hemisphere.

To meteor observers, perihelion signals the arrival of the Quadrantid meteor shower. Earth tunnels through the trail of a long-dead comet and sweeps up its dust, dooming the particles to death by fire in our upper atmosphere. The impact speed is 26 miles per second (42 km/s), which makes the streaks faster than last month's Geminids. This sharp-peaked shower occurs near New Moon, though a bit early in the night for optimal viewing.

After a lovely predawn conjunction with Venus and Mars on December 30, the crescent Moon graces the evening sky a few days later. It then passes by Saturn on the 15/16th, and meets Jupiter at full phase on the 18/19th.

The morning sky remains a place of action. If you're up before 6:30 A.M., watch how Venus and Mars slowly separate. Mars is the ruddy "star" to the upper right of blazing Venus. By the end of the month, a real orange star, Antares, enters the picture, but below Mars. Antares literally means the rival of Mars. The two are very similar in brightness this month, but that will change as the Earth-Mars distance lessens.

Brisk January evenings see the return of Orion to the evening sky. Frank Zullo

The waning crescent Moon joins Mars on the 27th and Venus on the 28th, and becomes wafer thin all alone on the 29th. Another surprise this last morning: Mercury has popped up to join the morning crowd and is two binocular fields to the Moon's left. There's no other bright object in the area to confuse the identification.

Comet C/2001 RX14 (LINEAR) reaches its maximum brightness this month as it arcs beneath the bowl of the Big Dipper. Because it is a fairly small comet at twice Earth's distance from the Sun, you'll need dark skies and at least a 4-inch scope to track it down.

2003
January

1 Asteroid Davida is at opposition, 6 P.M. EST

2 New Moon is at 3:23 P.M. EST

3 The Moon passes 5° south of Mercury, 6 P.M. EST
Earth is at perihelion (91.4 million miles from the Sun), midnight EST
4 Quadrantid meteor shower peaks (page 68)

The Moon passes 5° south of Neptune, 2 P.M. EST
Saturn transits the Crab Nebula (page 67)

5 The Moon passes 5° south of Uranus, 8 P.M. EST

10 First Quarter Moon is at 8:15 A.M. EST
The Moon is at apogee (251,247 miles from Earth), 7:42 P.M. EST
Venus is at greatest western elongation (47°), 10 P.M. EST

11 Mercury is in inferior conjunction, 3 P.M. EST

15 The Moon passes 3° north of Saturn, 3 P.M. EST
Venus passes 8° north of Antares, 5 P.M. EST

18 Full Moon is at 5:48 A.M. EST

19 The Moon passes 4° north of Jupiter, 10 A.M. EST

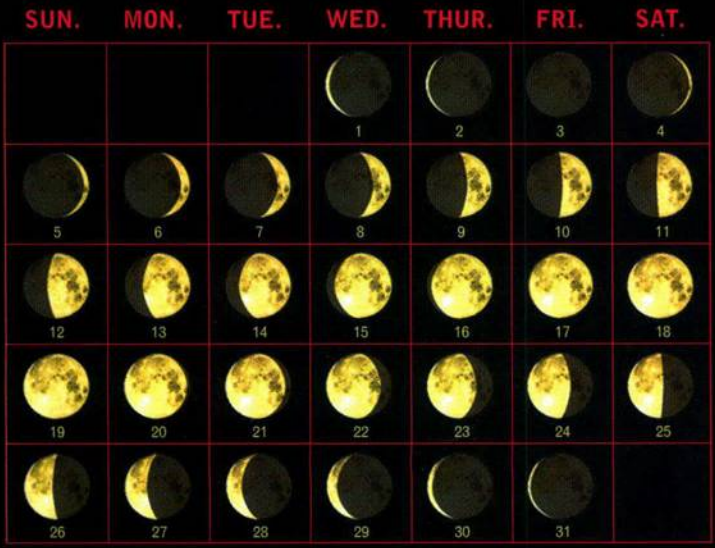
23 The Moon is at perigee (229,844 miles from Earth), 5:29 P.M. EST

25 Last Quarter Moon is at 3:33 A.M. EST

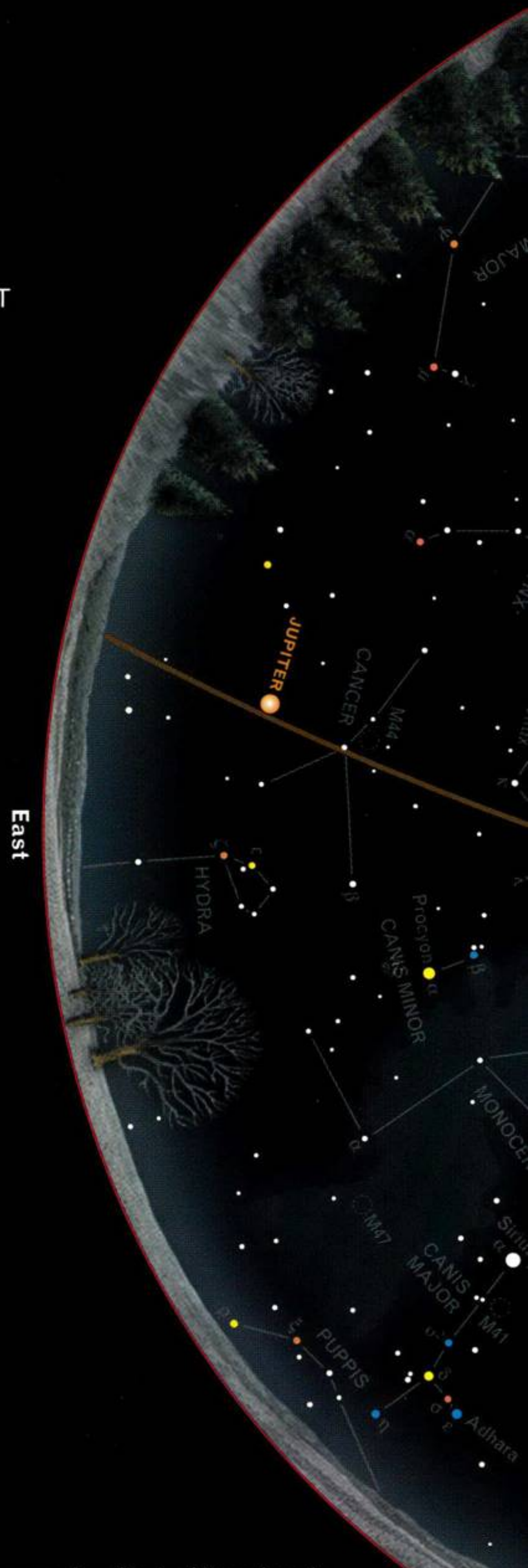
27 The Moon passes 0.4° south of Mars, 10 A.M. EST

28 The Moon passes 4° south of Venus, 2 P.M. EST

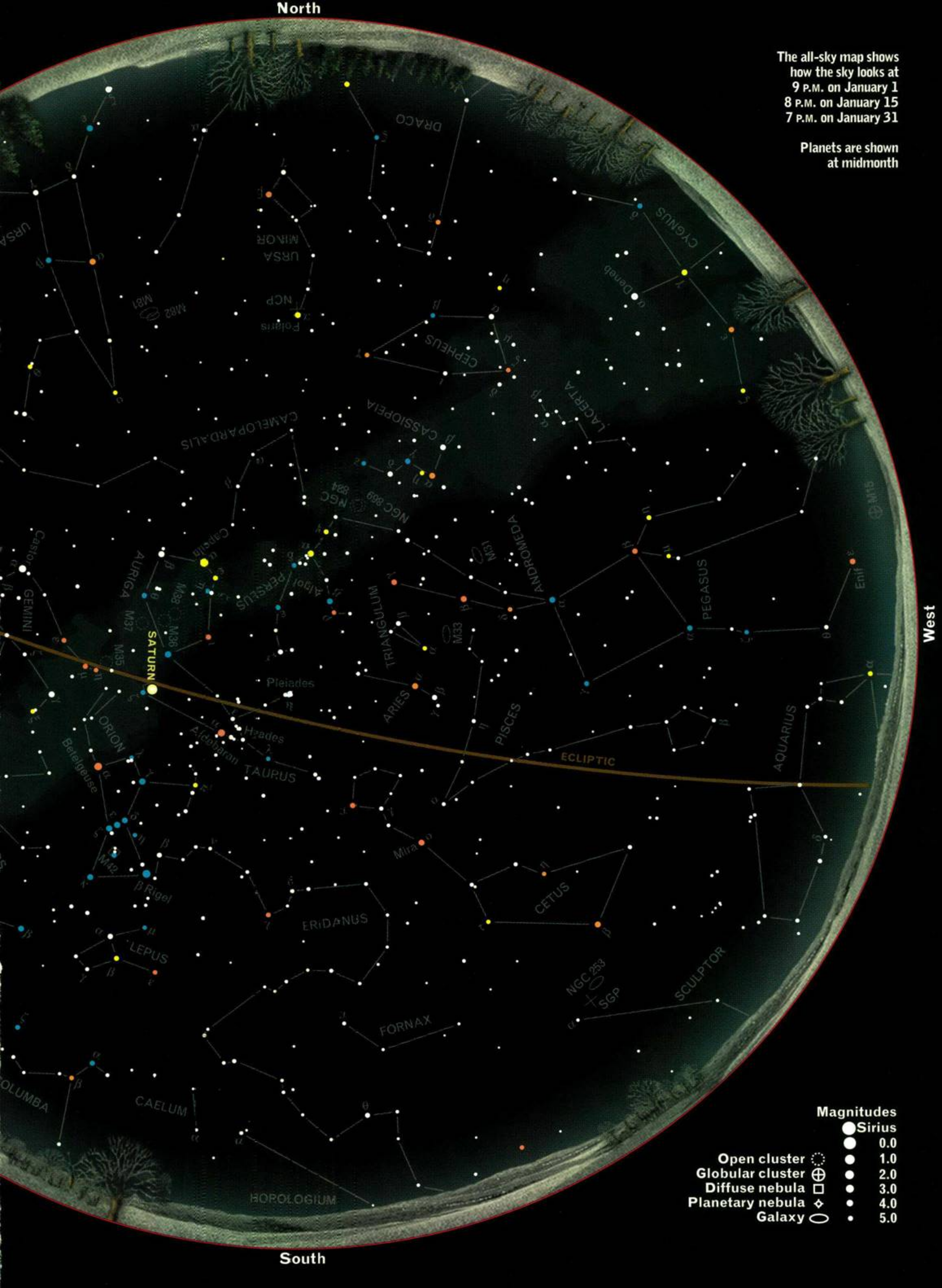
30 The Moon passes 5° south of Mercury, 5 A.M. EST
Neptune is in conjunction with the Sun, 7 P.M. EST
Mars passes 5° north of Antares, midnight EST (page 66)



SUN.	MON.	TUE.	WED.	THUR.	FRI.	SAT.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	



This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

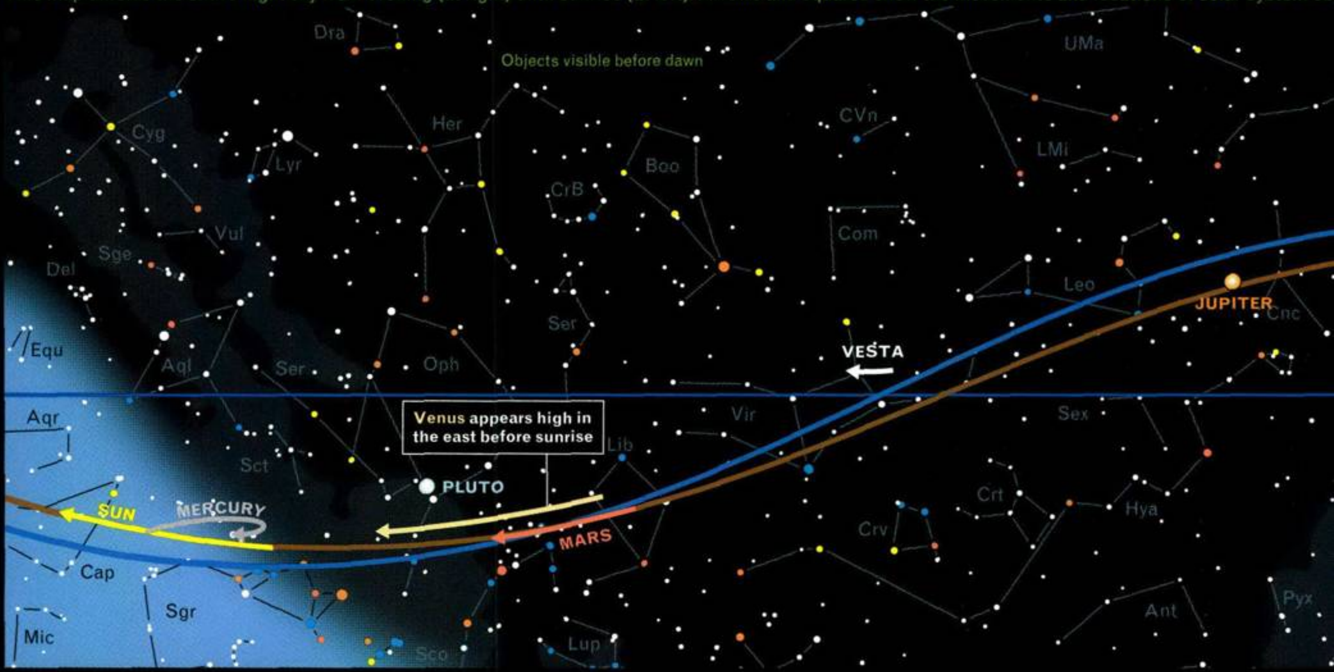

North
South
West
DRACO
URSA MINOR
URSA
NCP
Polaris
M81
M82
CYGNUS
Deneb
CEPHEUS
LACERTA
CASSIOPEIA
CAMELOPARDALIS
NGC 869
NGC 884
Castor
GEMINI
Capella
AURIGA
PERSEUS
Algol
ANDROMEDA
M31
M33
TRIANGULUM
PEGASUS
Enif
M15
M35
M36
M37
M38
SATURN
Pleiades
Hyades
Aldebaran
TAURUS
ORION
Betelgeuse
M42
Rigel
ARIES
PISCES
ECLIPTIC
AQUARIUS
Mira
CETUS
ERIDANUS
LEPUS
NGC 253
SGP
SCULPTOR
FORNAX
COLUMBA
CAELUM
HOROLOGIUM
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

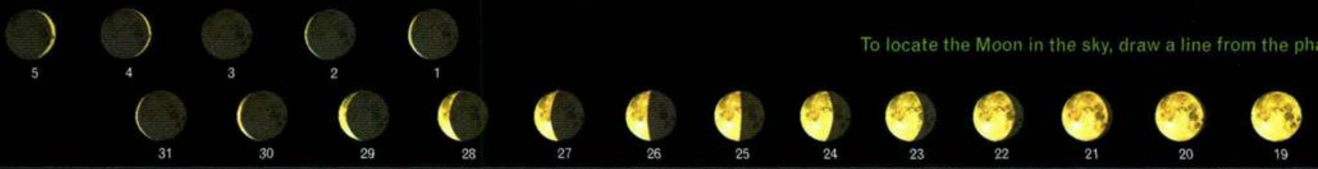
The all-sky map shows
how the sky looks at
9 P.M. on January 1
8 P.M. on January 15
7 P.M. on January 31

Planets are shown
at midmonth

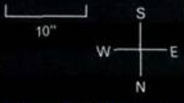
Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system ob

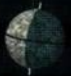

Dra
Objects visible before dawn
UMa
Cyg
Her
CVn
LMi
Lyr
CrB
Boo
Vul
Com
Sge
Del
Leo
JUPITER
Cnc
Ser
VESTA
Equ
Aql
Ser
Oph
Aqr
Venus appears high in the east before sunrise
Vir
Sex
Lib
Sct
PLUTO
Crt
Hya
SUN
MERCURY
Crv
MARS
Cap
Sgr
Ant
Pyx
Mic
Lup
Sco

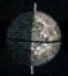

5
4
3
2
1
31
30
29
28
27
26
25
24
23
22
21
20
19

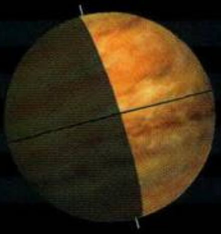
To locate the Moon in the sky, draw a line from the ph

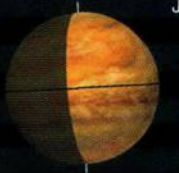


PLANETS	MERCURY	MERCURY	VENUS	VENUS
Date	January 1	January 31	January 1	January 31
Magnitude	0.1	0.0	−4.5	−4.3
Angular Size	7.9"	7.3"	27.9"	20.2"
Illumination	36%	54%	45%	60%
Distance (AU) from Earth	0.849	0.924	0.597	0.825
Distance (AU) from Sun	0.316	0.416	0.718	0.720
Right Ascension (2000.0)	20h01.2m	19h07.6m	15h28.7m	17h38.0m
Declination (2000.0)	−20°44'	−21°01'	−15°14'	−20°32'



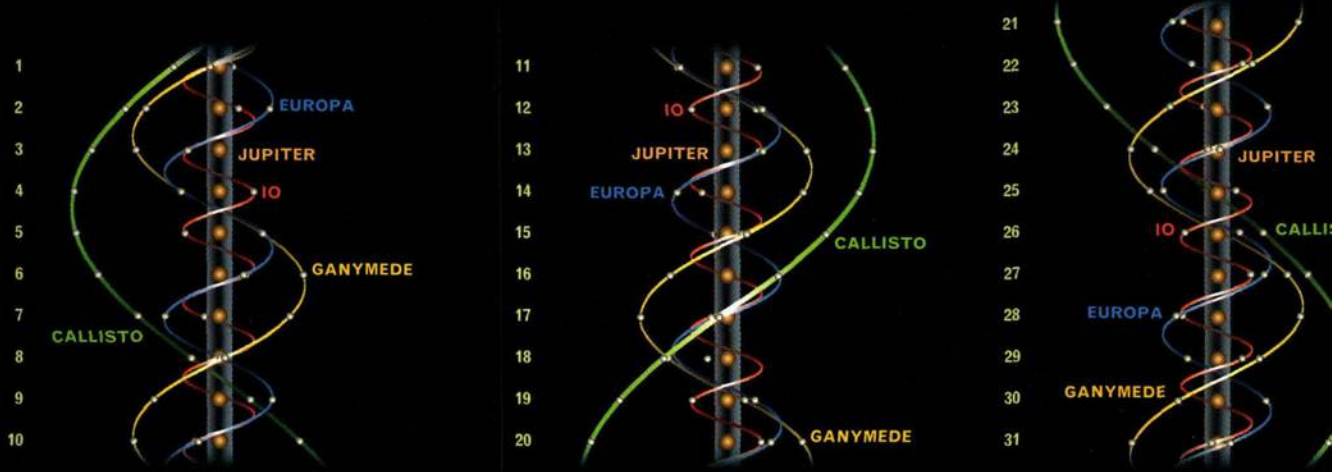




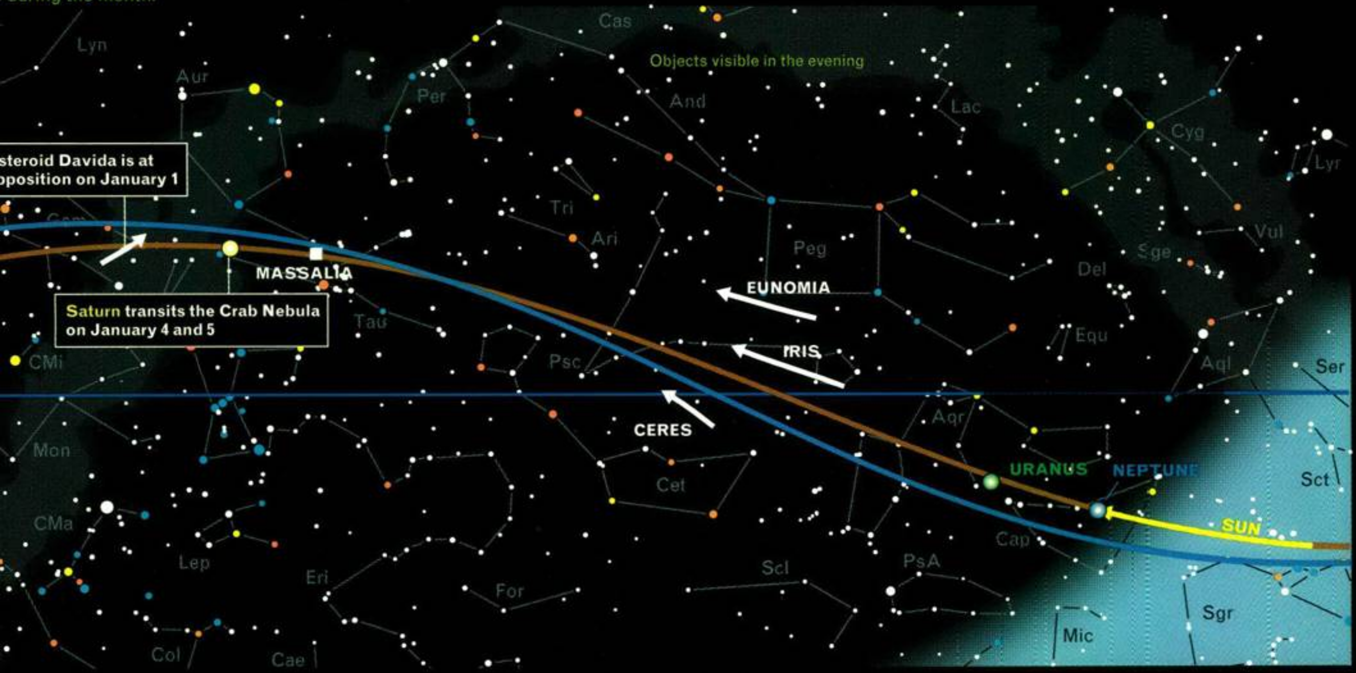


Jupiter's Moons

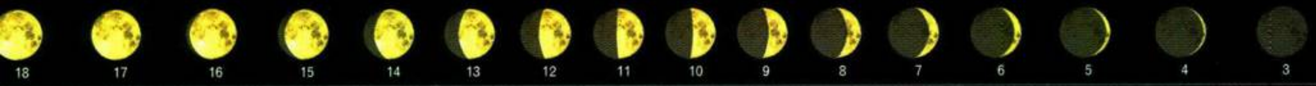
Dots display positions of Galilean satellites at 11 P.M. EST on date shown. South is at top to match the view in a telescope.


1
2
3
4
5
6
7
8
9
10
EUROPA
JUPITER
IO
GANYMEDE
CALLISTO
11
12
13
14
15
16
17
18
19
20
IO
JUPITER
EUROPA
CALLISTO
GANYMEDE
21
22
23
24
25
26
27
28
29
30
31
JUPITER
IO
CALLI
EUROPA
GANYMEDE

s during the month.


Lyn
Cas
Aur
Per
Objects visible in the evening
And
Lac
Cyg
Lyr
steroid Davida is at
pposition on January 1
Gem
Tri
Ari
Peg
Vul
Sge
Del
MASSALIA
EUNOMIA
Saturn transits the Crab Nebula
on January 4 and 5
Tau
Equ
CMi
Psc
IRIS
Aql
Ser
CERES
Aqr
Mon
URANUS
NEPTUNE
Sct
Cet
SUN
CMa
Cap
Lep
Eri
Scl
PsA
For
Sgr
Mic
Col
Cae

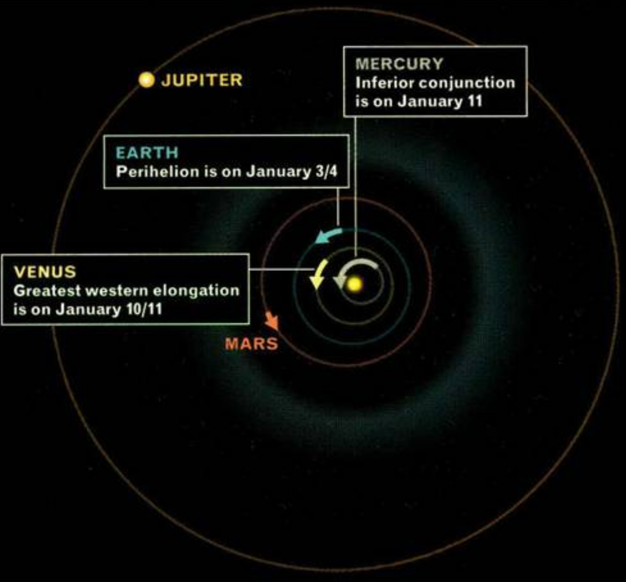
shown for the day straight up to the curved light-blue line.


18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3

RS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
ary 15	January 15	January 15	January 15	January 15	January 15
4	−2.6	−0.3	5.9	8.0	13.9
3"	45.0"	20.3"	3.4"	2.2"	0.1"
%	100%	100%	100%	100%	100%
33	4.377	8.177	20.838	31.030	31.384
03	5.307	9.035	20.016	30.084	30.600
5.8m	9h12.5m	5h31.5m	21h57.4m	20h49.9m	17h14.2m
°17'	17°00'	22°02'	−13°13'	−17°42'	−13°47'

The Planets in Their Orbits

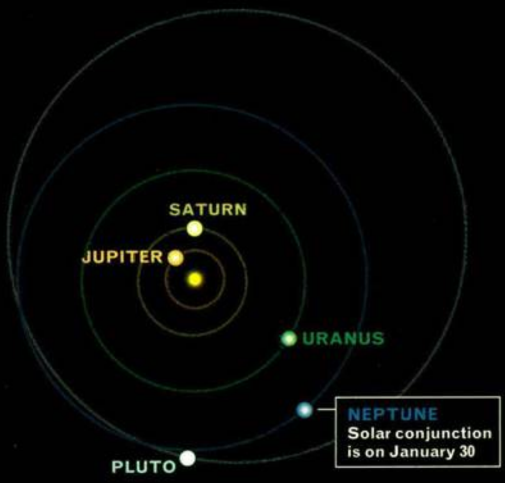
Arrows and dots show planets' positions during the month.


JUPITER
MARS

MERCURY
Inferior conjunction is on January 11

EARTH
Perihelion is on January 3/4

VENUS
Greatest western elongation is on January 10/11


SATURN
JUPITER
URANUS
PLUTO

NEPTUNE
Solar conjunction is on January 30

Appearances Can Be Deceiving

The Alcor and Mizar pair perched at the peak of the Big Dipper's handle has been known since the nights of antiquity. It is often said they were used to test the eyesight of potential court astrologers. Without my glasses, I would certainly fail, but with them, the 12' separation is no problem.

Imagine the surprise when an Italian astronomer, Giovanni Riccioli, noticed in 1650 that the bright star Mizar was itself a double, the first to be discovered. Since then the pair has been one of the most popular observing targets for amateurs. Data from the Hipparcos star measuring mission show that Alcor and the Mizar pair are about 78 light-years from Earth and moving in the same direction in space.

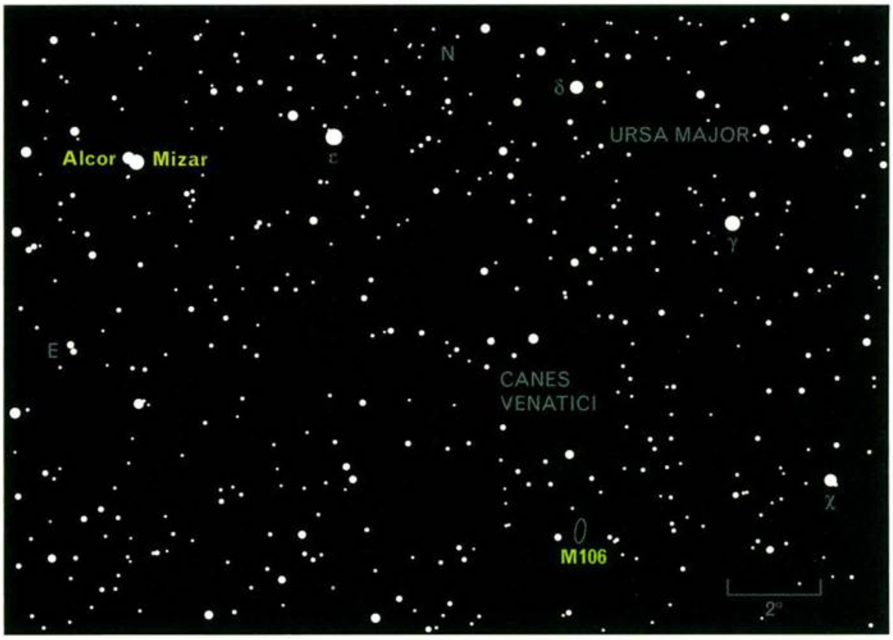
Interestingly, we know that the 9th-magnitude star in the same field of view is a background star, because it's heading off in a different direction.

Similar Spirals

Not far from Comet C/2001 RX14 (LINEAR) this month is the nearby, large spiral galaxy M106. In the smallest telescopes under a dark sky, Messier 106 is a readily noticeable oval fuzz glowing at magnitude 8.3. It reminds me a lot of Andromeda's great galaxy M31, except I can see the faint outer regions of M31. Spiral galaxies come in many variations, ranging from tightly coiled pairs of arms to loose multi-armed systems. M31 and M106 are the same type, which shouldn't be surprising because they look pretty much the same.

On the other hand, the grand face-on Whirlpool Galaxy (M51) in Canes Venatici looks very different in the eyepiece. But professionals are careful to class the objects and recognize that M51 is the same type as M106 and M31. If you could tilt M51 on its side, you would see an M31-like object. M106 and M51 are both about 36 million light-years away, roughly ten times farther out than the Andromeda Galaxy.

In a modest-sized 8-inch (20cm) scope, M106 begins to show some detail. Bump the power above 150x, because it's the only way to see faint detail. Use a dark hood to keep out stray light and increase the sensitivity of your eyes. You should be able to see that one end is not the same as the other — the spiral arms are not perfectly symmetric. If you slide your scope one apparent moonwidth (30') to the west you should see a small blur flanked by a star. This is NGC 4217, glowing at magnitude 11.2.



The spiral galaxy M106 makes a fine target for backyard observers. Bob and Janice Fera

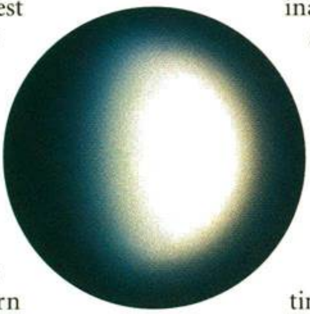
To get your best views of these galaxies and the comet, you should observe at the start or end of the month, to avoid moonlight, and far from the interfering glow of city lights.

It's giant planet season for the next few months. Jupiter and Saturn dominate the evening sky, making it dazzle with more than its usual brilliance. Mercury joins the early evening planetary parade and then returns briefly in the morning sky at the end of January, giving those of you with new holiday-gift telescopes plenty to focus on.

Mercury is always a challenging object because it lies so close to the Sun. It makes a brief appearance in the evening sky at the turn of the year. Mercury was at its best on December 26 when it stood 20° away from the Sun and set 80 minutes after our star. Shining at magnitude –0.5, Mercury was an easy planet to spot. But these things change quickly. By New Year's Day, Mercury stands 8° above the southwestern horizon about forty minutes after sunset and has faded to magnitude 0.1. It appears lower and dimmer each night following January 1, making the planet difficult to view even for those with a flat horizon. Mercury continues to slide into twilight, passing inferior conjunction on January 11 and returning to the morning sky three weeks later.

Once Mercury sets, it's time to turn your attention to the opposite direction. There, shining above the eastern horizon, you'll see **Saturn**. It's easy to find, even from the city, if you have a clear view to the east. Look for the cluster of stars called the Pleiades, or Seven Sisters. Directly below it is the brightest star in Taurus, Aldebaran. Saturn lies to the lower left of Aldebaran, near Zeta (ζ) Tauri, the star at one tip of the horns of Taurus the Bull.

If you have a new telescope, Saturn is one planet you don't want to miss. Your first view will capture your imagination like no other in the sky, and set you on a lifelong love for astronomy.



As Venus passes greatest elongation this month, it starts to show a gibbous phase. Charles Capen

This winter is the best time to view Saturn for a few reasons. First, it reached opposition on December 17, a position diametrically opposite the Sun in our sky and the best time to view the planet. This places Saturn in our sky all night. Second, Saturn is close to perihelion, the closest point to the Sun in its orbit. This puts Saturn closer to Earth than it has been in nearly 30 years. Finally, the rings are tilted at their maximum toward us, making Saturn both bright and spectacular. January opens with Saturn shining at magnitude –0.4.

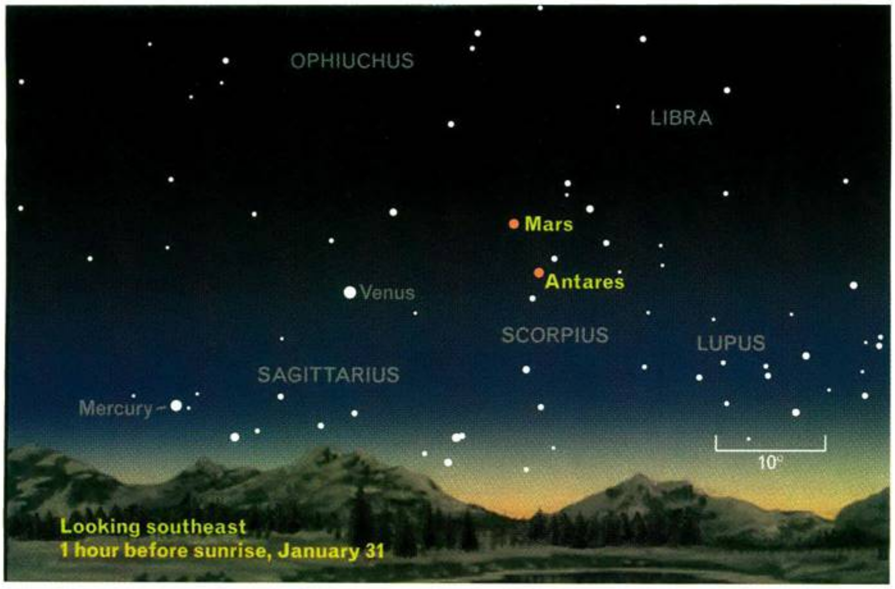
On January 4, Saturn passes in front of the Crab Nebula (M1), the remnant of an ancient supernova. Although the nebula is much fainter than Saturn, thus making it hard to see, CCD imaging may have the dynamic range to capture the moment. Later in the month look for the nearly full Moon standing near Saturn on January 14 and 15.

The major axis of the rings spans 46", and the planet itself is 20" wide. Small telescopes will reveal the rings easily, along with the Cassini Division that separates the two main rings, rings A and B. Telescopes larger than 6 inches in diameter will begin to show some of the subtle detail in Saturn's atmosphere. Such features are difficult to spot, because the variations in intensity are minor, but occasionally bright white spots appear, indicative of fairly long-lasting storms.

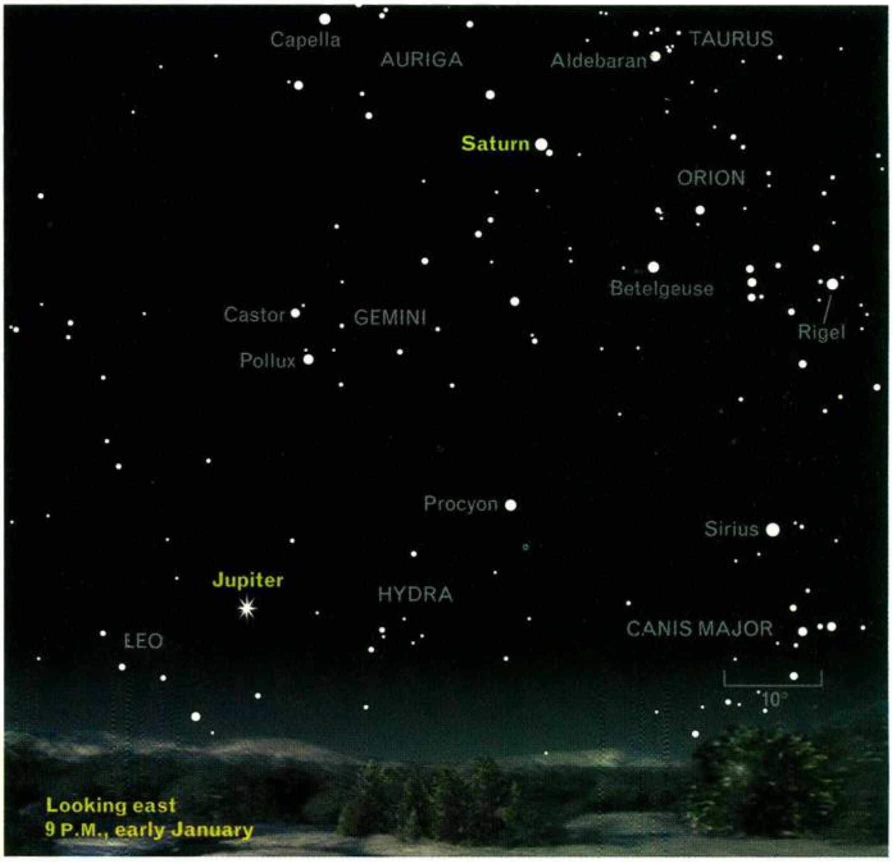
Saturn's moons are easy to track in telescopes larger than 6 inches. Tethys, Dione, and Rhea shine at magnitude 10.2, 10.4, and 9.7, respectively. Mimas, the closest of the major moons to Saturn, shines at magnitude 12.9 and should be visible under good sky conditions with an 8-inch scope. Any telescope will show you Titan, Saturn's largest and brightest moon, glowing at magnitude 8.3.

Iapetus brightens over the course of the month as its brighter hemisphere comes into view. Its orbit carries the odd moon from east of the planet, where it shines at magnitude 11.9, over to the west. For the first week of January it remains dim as we view its darker hemisphere. Iapetus moves slowly to the north of Saturn by late January, brightening as it goes. It will be mid-February before it reaches its brightest, magnitude 10.1, on the western side of the planet.

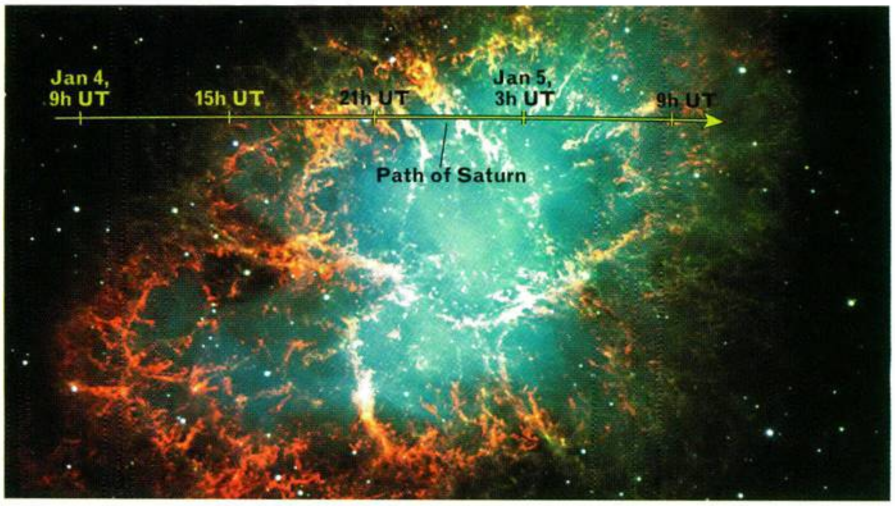
If Saturn's disk looks bland through your telescope and you want to turn to something different, try **Jupiter**. The giant planet rises in the east-northeast as twilight falls over the landscape. Its dazzling globe, shining at magnitude –2.6, is the brightest object in the sky aside from the Moon. Low-power binoculars will show Jupiter lying 9° east-southeast of M44, the wonderful Beehive star cluster in Cancer.



Looking southeast
1 hour before sunrise, January 31



Looking east
9 P.M., early January



Wait until about 10 P.M. for good telescopic views, when Jupiter has climbed high enough to be less affected by turbulence in our atmosphere. Such "bad seeing" can significantly affect your view of any planet.

Jupiter's atmosphere is dynamic like Saturn's but not hidden by haze, so features are clearly visible. The highest contrast features are the equatorial belts lying north and south of the equator. Because the entire planet's visible face rotates in less than 10 hours, careful observers will notice a change of position of prominent features within 15 to 20 minutes. Every four hours an entirely new hemisphere will be on view.

Jupiter will reach opposition on February 2. By the end of January its apparent diameter has grown to 46", the maximum size for the year. This renders atmospheric details visible on a scale suitable even for small telescopes.

The relative positions of Jupiter's moons change constantly. Callisto is currently undergoing a series of rare eclipses, occultations, and transits, and those timings appear on the next page. Watch our own Moon standing near Jupiter on January 18 and 19.

Venus and Mars begin the month near each other in the constellation Libra the Scales. Following their close conjunction last month, Venus begins to pull away from Mars as their independent motions take them in different directions. They both become visible in the southeast about three hours before sunrise. **Venus** is most obvious, shining extremely brightly at magnitude –4.4. Through a telescope, Venus exhibits a half-moon phase. It reaches dichotomy (exactly 50 percent illuminated) on January 10. What date do you think Venus looks exactly at half phase? By the end of the month it appears 60 percent lit.

Throughout the month, Venus slides away from Mars and moves toward the Sun, becoming lower at each dawn. It crosses northern Scorpius between January 9 and 14 and spends the rest of the month in Ophiuchus.

Mars begins the month shining at magnitude 1.5, and moves more slowly than Venus across Libra and Scorpius. It appears to the upper right of Venus in the predawn sky. On January 25 Mars has brightened to magnitude 1.3 and rivals Antares, lying 5° south. Antares shines at magnitude 1.0. This is the perfect juxtaposition of the pair. When translated, Antares means "rival of Mars."

Mars doesn't show any features telescopically yet, because it lies too far from Earth. Just wait until this summer when we will be treated to a Mars spectacular. Watch the waning crescent Moon stand near Mars on January 27, and near Venus on January 28. By January 29, the thin sliver of a Moon stands 13° to the right of 0.1-magnitude Mercury, which has just reappeared in the morning sky.

sky Show

Meteors and Moons

A Nice but Short-Lived Shower

The annual Quadrantid meteor shower peaks around midnight on January 3/4. With New Moon on January 2, conditions couldn't be better, so long as the local weather plays along. The shower is best viewed before dawn when the radiant is highest for Northern Hemisphere viewers, meaning this year North American observers will see the tail end of the peak. Typical peaks can reach 100 meteors per hour if the radiant lies directly overhead. With a lower radiant, atmospheric extinction, and viewing a few hours past peak, observers might expect up to 30 meteors per hour. The Quadrantids are named after a defunct constellation, Quadrans Muralis, now part of northern Boötes.

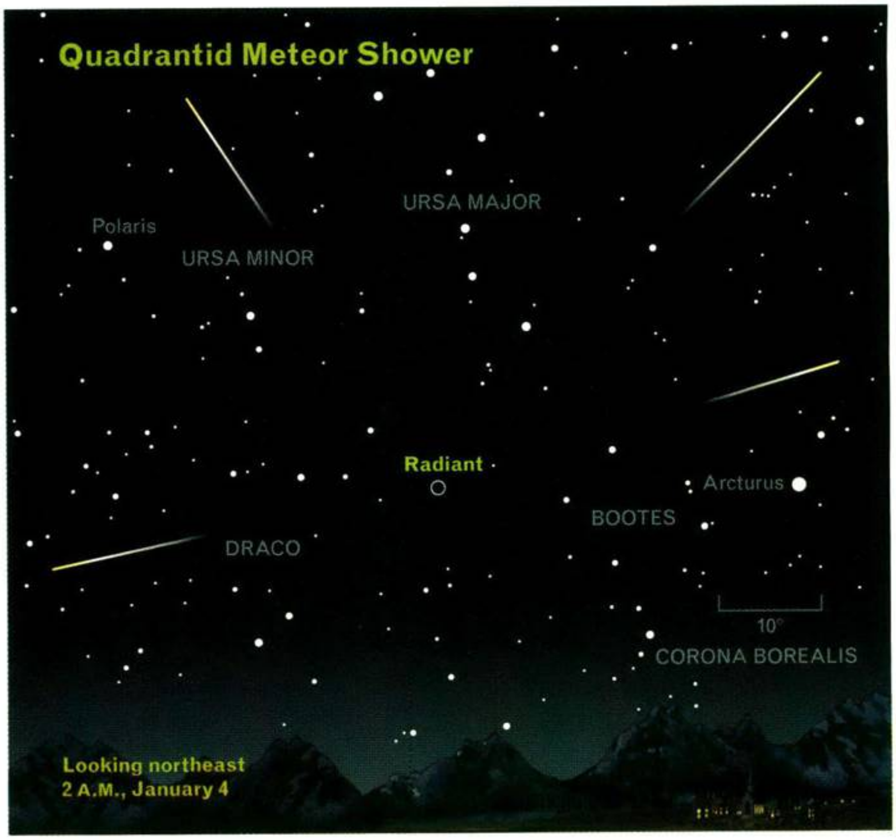
Bully on Bullialdus

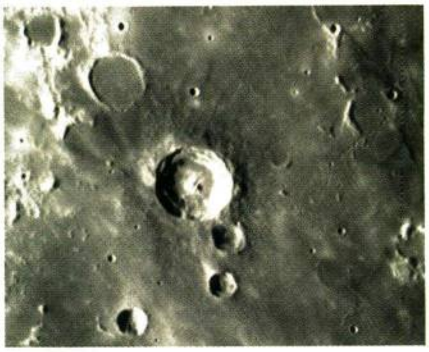
The 38-mile-wide (61-km) crater, Bullialdus, is a fine, classic crater. It stands out among the plains of Mare Nubium shortly after a First Quarter Moon. Resembling Copernicus, but smaller, Bullialdus has the classic signs of an impact crater: multiple central peaks, terraces, and radial ejecta ridges. Sunrise over the crater occurs during the third week of January. If you catch the timing right, you will see the first rays of the Sun strike the central mountain peaks. Their appearance changes dramatically with the changing Sun angle. The ejecta ridges are also especially prominent with a low Sun angle.

On the crater's southeastern rim, the 16-mile-wide (26-km) crater Bullialdus A sits among the flanks of the larger crater. Farther to the south lies a similar sized crater, Bullialdus B. It appears crisper than Bullialdus A, and hence is younger.

To the north-northwest of Bullialdus lies the ancient and partially buried crater, Lubiniezky. Note the series of bright streaks that runs across its flooded floor. One appears to align with another bright streak that runs at a tangent to the northeastern rim of Bullialdus.

East of Bullialdus is an amazing set of wrinkle ridges formed by past lava flows. Among the ridges are mountain peaks that jut proudly from the surface of Mare Nubium. These features are best viewed under very low Sun angles.





Terraced walls and multiple central peaks highlight the lunar crater Bullialdus. Gérard Therin

Jupiter's Satellites

The rare occultations, eclipses, and transits involving the outer Galilean moon, Callisto, continue. Events listed in the table are given in both Universal Time and Eastern Standard Time. Those that occur near midnight are shown twice because the date changes from Europe to North America. Tr = transit; Ec = eclipse; Oc = occultation; Sh = shadow transit; I = Ingress; E = Egress; D = disappearance; R= reappearance.

Catch Callisto

	UT	EST	Event
Jan 1	6:03	1:03 A.M.	IV.Tr.I.
	10:49	5:49 A.M.	IV.Tr.E.
Jan 9	6:45	1:45 A.M.	IV.Ec.D.
	11:37	6:37 A.M.	IV.Ec.R.
	12:14	7:14 A.M.	IV.Oc.D.
	17:05	12:05 P.M.	IV.Oc.R.
Jan 17	17:05	12:05 P.M.	IV.Sh.I.
	20:39	3:39 P.M.	IV.Tr.I.
	21:53	4:53 P.M.	IV.Sh.E.
		8:25 P.M.	IV.Tr.E.
Jan 18	1:25		IV.Tr.E.*
Jan 25		7:46 P.M.	IV.Ec.D.
Jan 26	0:46		IV.Ec.D.*
	7:21	2:21 A.M.	IV.Ec.R.

*** Events that occur on either side of midnight are shown twice.**

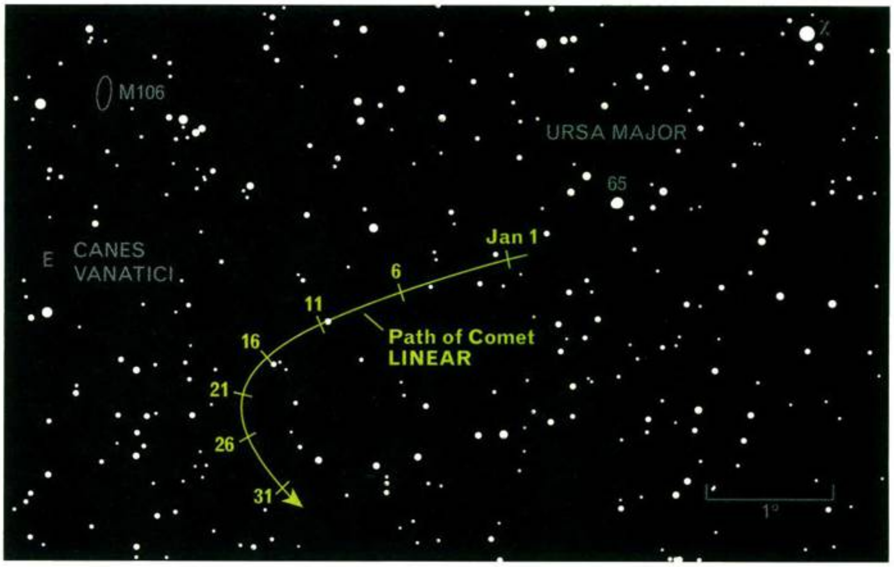
Comet LINEAR Curves

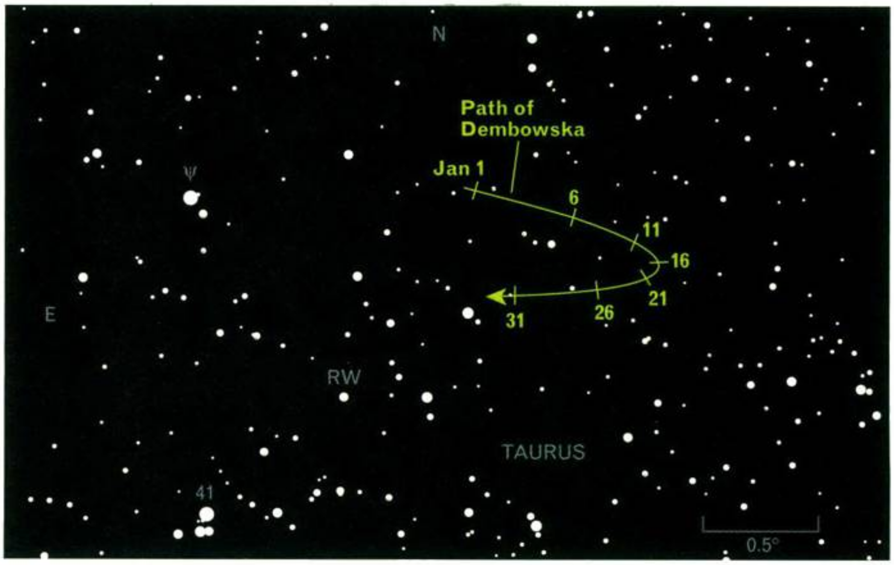
Discovered nearly two years ago, Comet C/2001 RX14 (LINEAR) is taking a slow pass through the inner solar system. Although it made its closest approach to the Sun last January, it's now twice as far out as Earth, so it moves more slowly. We are now catching up to it a bit, so it appears to be brightening despite its increasing distance from the Sun. Our changing perspective makes it do a sharp turn below the Big Dipper.

Glowing at about magnitude 11, RX14 (LINEAR) requires a nice dark sky to be seen. Plan your observing close to New Moon, at the beginning or end of January. Because it is riding low in the sky under the bowl of the Big Dipper, you'll need to wait until midnight for it to climb above horizon glow and murk.

Start your hop at Chi (χ) Ursae Majoris, and jump over to the 6th-magnitude star near the spiral galaxy M106. This galaxy is two magnitudes brighter than RX14 (LINEAR), so sharpen your skills on the galaxy first. Then use the chart to slide 2° to 3° over to the comet. If you are having trouble seeing it at low power, there may be too much skylight. Increase the power bit by bit and double check the chart to make sure you're in the right spot.

Use averted vision, the astronomer's trick of looking a bit to the side but paying attention to what's in the middle of the field. Look in a direction away from your nose, so that the object does not fall onto your eye's blind spot.





A High-Numbered Rock and a Ticker

The closer an asteroid is to us, the brighter it appears. Thanks to the elliptical orbit of 349 Dembowska, we get a chance to see it at its closest this year. It's fun to catch asteroids with numbers higher than 100 in a small scope.

Dembowska is looping westward in northern Taurus, above the Pleiades. Earth is in the process of overtaking it on the inside of the orbital racetrack. Start at Zeta, the bottom star of Perseus, and jump southeast a half binocular field to Pi (π) Tauri. Don't forget to have a look at the Pleiades while you're in the area.

Use the chart to slide your scope the 1.5° from Pi to the asteroid. You should be able to see which faint star doesn't belong. If you're unsure, make a quick sketch of the field, then come back again another night.

As a bonus, check out the eclipsing binary star RW Tauri nearby. Like the Demon Star, Algol in Perseus, RW has a darker companion that eclipses its brighter brother. It takes only four hours for RW to plunge from 8th magnitude down to 12.5 and back again. Have a look every 20 minutes and you're sure to notice the change. The eclipses take place every 2.769 days, and some of the better events for North American observers are listed at right (in UT). EST is 5 hours earlier, so minimum light on the 8th at 4 UT is 11 P.M. EST on the 7th.

RW Tauri minima

January 8	4.0 UT
January 10	22.5 UT
January 19	5.7 UT
January 22	0.0 UT
January 30	7.4 UT

Martin Ratcliffe is President of the International Planetarium Society. Alister Ling is a meteorologist for Environment Canada.

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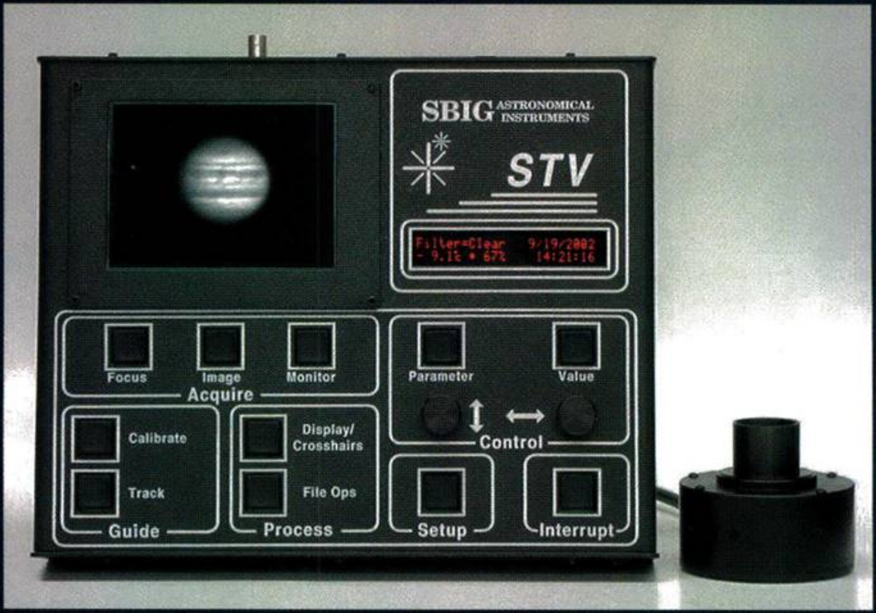
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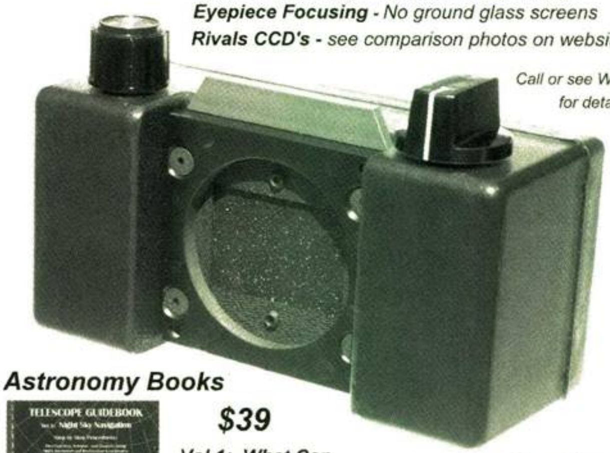

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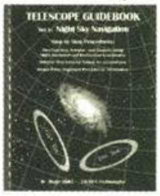

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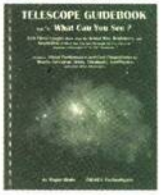

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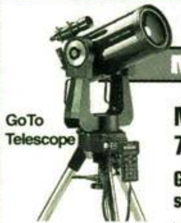

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What is the limiting visual magnitude for an astronaut in orbit on the nightside of Earth?

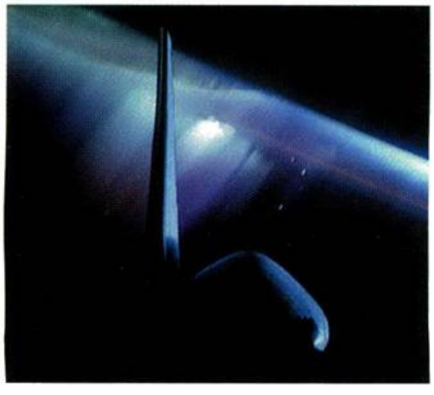
— Bert Mettier, Unterwasser, Switzerland

The term "magnitude" refers to a numerical system by which the brightnesses of stars and other celestial objects are measured. The brighter an object, the lower its magnitude.

Surprisingly, the limiting visual magnitude for an astronaut in orbit is not much fainter, maybe half a magnitude (slightly less than two-thirds as bright), than what you'd find on the ground under the best conditions. This means that you are rested and comfortable, your eyes are fully dark-adapted and looking straight up, the viewing site has no artificial light from any near or distant source, the night is moonless, the ground is bare, and no auroral display is going on.

Under such conditions, the average human eye can detect a star of magnitude 6.5 to 7. But individuals vary, and people with exceptional sensitivity may see nearly a magnitude fainter.

The problem with viewing stars from space is that you can't view them as unobstructedly as you can from deep in the heart of West Texas. For obvious reasons, stargazers in space have to look out the window of a space shuttle or through a spacesuit helmet. These absorb light and optically distort star images, both of which make faint stars harder to detect.



This time exposure of the Aurora Australis was photographed by the crew of the space shuttle *Endeavour*. NASA

Astronauts have experimented with viewing from inside the shuttle, but even with cabin lights turned off, instrument panels have readouts that keep a background level of illumination higher than full darkness on Earth. This prevents complete dark-adaptation. Also, keep in mind that "orbital night" lasts only 45 minutes, so even if you were viewing from outside the shuttle in a spacesuit, dark-adaptation is only partial. Although most of the sensitivity gain occurs in the first half-hour, the full process takes a couple of hours.

How about high-altitude sites? While excellent for instruments, high altitudes don't help humans much because the eye's sensitivity lessens as the amount of oxygen in the bloodstream drops. Atop Mauna Kea, for instance, each breath takes in only 60 percent of the oxygen that you get at sea level.

The bottom line is that while the atmosphere robs us of some starlight, it's not by much — perhaps half a magnitude. The real enemy of skygazers is light pollution, but that's another issue altogether.

— *Robert Burnham, Contributing Editor*

I understand that Neptune emits more light than it receives from the Sun. How is this possible?

— Dave Porter, Minneapolis

Yes, Neptune radiates about twice as much energy as it receives from the Sun, as do Jupiter and Saturn. Uranus, on the other hand, radiates just a few percent more than it receives. If the gas-giant planets were stars there would be no mystery, but even the largest gas giant in the solar system, Jupiter, is ten times too small to support nuclear fusion in its core. So if gas giants aren't even close to being stars, where's the extra energy coming from?

Neptune radiates more energy than it receives from the Sun. JPL/NASA

A related question is, where does the kinetic energy go when an object is dropped on a table? Some energy goes into sound waves, but most goes into heating the object and table slightly. This energy is quickly radiated away in the infrared. However, when the gas giants formed they "dropped" into themselves, and an enormous amount of kinetic energy got converted into internal heat.

The ability to store heat scales with volume, which is proportional to the cube of the radius, while the ability to radiate heat away scales with surface area, which is proportional to the square of the radius. This means large planets take a much longer time to cool down than small ones. (On Earth you can see this size effect in the heart rate of animals. Tiny ones like the shrew lose body heat much faster than larger animals like elephants, and thus their heart rates and metabolism run much faster.) Incredibly, even today, after over 4 billion years, the heat of formation is still percolating out of the gas-giant planets.

Some of the heat escaping from the gas giants comes from the fall of helium raindrops which, in a small way, continue the process of the planet

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falling into itself. It's interesting to note that Uranus has the smallest internal energy supply and the least-dynamic meteorology of the gas giants. It is also the only one tipped on its side. Quite possibly, these facts are all related. There is no connection known yet, but you might agree that the real mystery here is why Uranus radiates so little.
— Timothy E. Dowling, Assoc. Professor, Comparative Planetology Laboratory, University of Louisville

Why can't we see green stars? They are not on the Hertzsprung-Russell diagram, either.

— Bill Howe and Patricia Linden, Mahwah, New Jersey

You can't see green stars because there aren't any. You can, however, see stars as green. It's not the same thing.

As you proceed through the colors of the rainbow from red to orange, yellow, green, blue, and violet, you also go up in energy. Deep violet light carries about twice the energy of deep red. A star is basically a hot body that radiates its energy into space. The colors of the light it emits depend on its temperature, which is a measure of the energy of the radiating surface gases.

Stars can range in temperature from under 1000 kelvins (Celsius degrees above absolute zero) to over 100,000 kelvins. At low temperatures, stars can emit only low-energy radiation. A 1000 K star will radiate only in the infrared where we cannot see it. At 2000 K, however, a star radiates higher-energy visible red light as well as infrared. As temperature rises, the star emits more and more toward the violet end of the rainbow. If hot enough, it will radiate in the ultraviolet. At the same time, it is emitting ever-more low-energy radiation also.

The eye takes all these colors and combines them into more subtle shades. Cool stars will appear reddish or orange-red. Warmer ones, 4000 to 5000 K, may take on a yellowish or yellow-orange cast. At a temperature where the star produces a lot of green light, the human eye just combines all the colors into white. At the high-temperature end, we see a star as bluish-white. Green, in short, just gets skipped over.

The only solitary star that appears green is Zubeneschamali (Beta Librae), but it looks just white to me. However, the eye can be fooled. If you place two subtly-colored stars in proximity (as in a double star), and contrast effects make the colors appear richer, then one of the stars (usually the fainter one) looks green. However, it's an illusion.

The classic case is Antares, the red supergiant that hovers over a much fainter blue-white companion. The latter consistently has the reputation of looking green. But this is caused by the eye reversing itself due to the overwhelming reddish light of Antares.
— Jim Kaler, University of Illinois (check out Jim's "Star of the Week" at www.astro.uiuc.edu/~kaler/sow/sow.html)

Antares, a red supergiant star, lies in the heart of the constellation Scorpius. John Chumack

The SETI program is searching for radio signals from other planets. How can these signals be strong enough to reach us from far off in space when I can only occasionally get a full strength signal on my cell phone?

— Frank S. Young, Country Club Hills, Illinois

Generating radio signals that can be detected even at distances of thousands of light-years is actually quite straightforward. There are three advantages that interstellar broadcasters have in comparison to your cell phone:

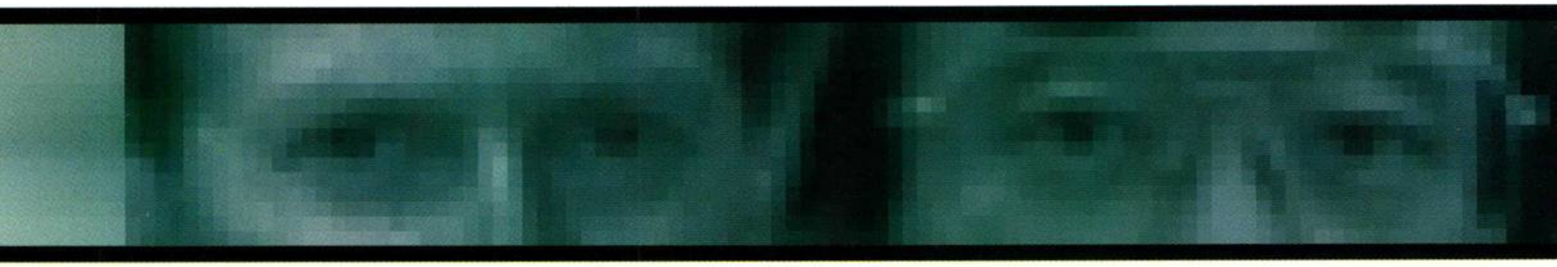
(1) They don't have to work through walls or rocky terrain. Your phone has to work even when you're inside a massive building, in the shadow of a hill, etc. Interstellar communications can be line-of-sight, of course, since everyone would be sure to put both transmitters and receivers out in the open.

(2) Powerful signals are easy to create. It's not hard to build transmitters with very large power output: millions of watts or more. We can do this today, only a century after inventing radio. Advanced aliens will have even more wattage at their disposal.

(3) Line-of-sight communications is expected. The most important point is that by using large antennas, radio waves can be directed, or concentrated, in one direction. This can have a very significant effect. In the case of the 1,000-foot Arecibo antenna operating at a wavelength of 21 cm, the directivity is 10 million. In other words, anyone in the beam of this telescope (when used in transmitter mode) will get a signal 10 million times stronger than if it were broadcast in all directions. This is similar to the difference between using a searchlight in place of a bare bulb.

In practice the SETI Institute's Project Phoenix can detect a signal from 100 light-years away if the extraterrestrials use a transmitting antenna the same size as the one at Arecibo, and a transmitter power of only ten kilowatts. That's not very much: AM and FM radio stations typically use much more power. This demonstrates how efficient radio communication between the stars can be.

While your cell phone isn't ideal for for chatting with aliens, radio dishes around the world are ready to receive.
— Seth Shostak, Senior Astronomer, SETI Institute



THE COMET SEEKERS

Ever dreamed about finding a comet of your own?
Learn how to bag and report your discovery from 10 veteran comet hunters.

by Tom Polakis

From the undulating foothills of the Sierra Nevada western slope, Don Machholz completes another serene yet fruitless night of comet searching. The truth is, he hasn't felt the rush of discovery for eight years. Finding another comet is going to be a challenge, especially with the recent spike in competition from those quick-draw, silver-skinned new kids 1,000 miles away in New Mexico.

Meanwhile, a pair of those tireless upstarts has also completed another night of comet hunting. The twin one-meter telescopes called GEODSS (Ground-based Electro-Optical Deep Space Surveillance) have had a record-breaking four years. Outfitted with CCD cameras capable of covering two square degrees and reaching 20th magnitude in less than two minutes of exposure, the scopes, part of the Lincoln Near-Earth Asteroid Research (LINEAR) project, continually survey a quarter of the sky in search of threatening objects that may venture too close for comfort to Earth.

While uncovering potential killer asteroids and other minor planets, the LINEAR survey sometimes dredges up unknown comets. In addition to more than 150,000 new asteroid discoveries in its first four years of operation, the LINEAR project christened 82 comets with its name. When LINEAR isn't discovering comets, similar surveys such as LONEOS (Lowell Observatory Near-Earth Object Search) and NEAT (Near-Earth Asteroid Tracking) are.

Do these automated surveys signal a death knell for amateur comet discoveries? Some say yes. Only one amateur comet each year was confirmed in 2000 and 2001.

But Machholz and his comet-hunting compatriots refuse to be discouraged. Despite an initial turn-of-the-century downward trend, amateurs swept up three comets in the first quarter of 2002 alone. This suggests there is still a place for the dedicated, warm-blooded comet seeker.

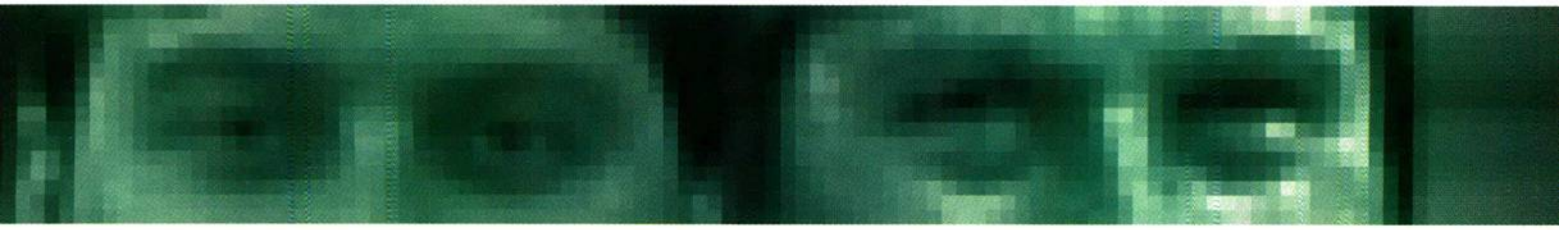
Right Place, Right Time

On the morning of August 18, 2001, Vance Petriew was fortunate to be looking in the right place at the right time. He was collecting first light with his new 20-inch scope under dark skies at the Saskatchewan Summer Star Party. Still up at 4 A.M., after most attendants had packed their gear, Petriew went after the Crab Nebula (M1). He began to star hop from Beta Tauri, only to find a fuzzy object that wasn't the Crab. Luckily, Rick Huziak, a 32-year veteran of the hobby, dropped by to ask what he was viewing. Huziak quickly identified it as a comet, and the activity picked up. Within an hour, the new comet had moved 2', and still they had not identified it as a cataloged comet. Before the star party's Saturday evening presentation, Petriew made a stunning announcement to a full auditorium: He thought he had discovered a new comet. Its official designation would be Comet P/2001 Q2 (Petriew).

Accidental discoveries like Petriew's are not only a result of luck but also the tenacity to get out there and scan the sky. Australian Steve Lee tells a story similiar to Petriew's. An active amateur astronomer since his early teens, Lee has built over 30 telescopes. He's also lucky enough to work in an observatory environment, which enables him to live in a home with a dark yard. In 1999 he found his comet.

Rather than taking a coffee break with the rest of a group of star party attendees, Lee stayed out to take a look at the planetary nebula NGC 5189 in the constellation Musca. The next day he would be giving a presentation about his role as a night assistant at Siding Spring Observatory. He planned to feature images of NGC 5189, and he wanted a visual impression. While

Amateurs have beat robotic surveys to spot recent comets, including Ikeya-Zhang (large image and left-most inset), C/1999 H1 (Lee), C/1997 T1 (Utsunomiya), and C/1997 N1 (Tabur). Chris Schur



Steven Lee was looking for a planetary nebula when he stumbled across a new comet. Melissa Hulbert

Shigeki Murakami resumed his sweeps after an encouraging discovery by Kaoru Ikeya. Shigeki Murakami

Vance Petriew (above with daughter Emily) was at a star party when he spotted a comet. Jennifer Petriew

Despite the glare of a bright Moon, Peter Williams glimpsed a comet during a nova search. Linda Williams

star hopping, Lee came across a suspicious cometary object 3° from his target. Within five minutes, Lee detected motion against the starfield. The next day a new comet was confirmed — C/1999 H1 (Lee).

Like Petriew and Huziak, Lee did the right things after spotting his comet: He kept his cool, and before making the call to the Central Bureau to report it (see "Your Name Here," page 77), he pored over star charts to ensure it was not an impostor — a galaxy or globular cluster. Next he looked for motion, and verified that it was not a known comet. Finally, he estimated its coordinates and plotted its motion. Lee says having the Central Bureau's telephone number and e-mail address handy can separate comet discoverers from near-discoverers.

Variable Veterans

But let's face it — comet discoveries at star parties are rare. Lee's and Petriew's were the only ones from 1996 to 2001. Most accidental finds belong to variable star observers.

From the outskirts of Sydney, Australia, Peter Williams has reported more than 70,000 variable star observations since 1971. He observes at least one out of every three nights. You might say it was only a matter of time before a new comet would find him. After more than six inches of rain fell during the first nine days of August 1998, Williams used the first clear night to return to the sky. The Moon was nearly full.

After 10 observations, Williams had worked his way to the field of dwarf nova EK Trianguli Australis. There he encountered a cometary haze that noticeably moved over a half-hour period. He notified the Central Bureau, and on August 12, got his comet: 1998 P1 (Williams). To this day, he still has not seen his original target, the dwarf nova.

Williams jokes, "I like to believe that I have been conducting a systematic search for comets in variable star fields — while looking in the wrong direction and under a Full Moon. Clearly, my methods have been vindicated!" Today, Williams occasionally sweeps for comets, but his focus remains variable stars.

Not far away in South Australia, Justin Tilbrook discovered his first comet in 1997 — C/1997 O1 (Tilbrook) — after logging 700 hours observing variable stars. This experience recast him as a comet hunter. Encouraged by the world's most prolific visual comet finder, Bill Bradfield, Tilbrook made his second discovery a year-and-a-half and less than 100 observing hours later — C/1999 A1 (Tilbrook).

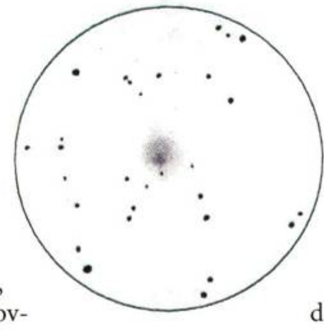
Tilbrook searches with an 8-inch scope modified for comet hunting with motion limiters at the ends of the azimuth arc that prevent sweeping too far. A red light reminds him when he's sweeping counterclockwise, and digital setting circles identify deep-sky objects masquerading as comets. Looking like a Springfield mounting, his modified altitude bearing passes through the eyepiece to stave off neck problems. The result, he says, "looks like the starboard engine of the starship *Enterprise* with a weight set thrown in."

Australian software engineer Vello Tabur has dreamed about discovering comets since 1978. He modified his 8-inch Newtonian for comfortable sweeping. On a sub-freezing August night at his site near Canberra, he bagged his first comet. During the night, he came across a 10th-magnitude object in Eridanus, and by morning twilight, motion was apparent. After a long day, his find was confirmed — C/1996 Q1 (Tabur).

Tabur then took a break from comet hunting for a few months only to realize he missed it. He was hooked. He made his second discovery on a July morning after being back at the eyepiece for only 28 hours. A half-hour before morning twilight, the visitor, named C/1997 N1 (Tabur), appeared in the scope.

Tabur currently monitors the sky with a 100mm telephoto lens and a CCD camera. While he could cover more sky observing visually, his "mini-LINEAR" system is less fatiguing, and he can search from his suburban home. While he has not found any new comets in 350 hours, his images yielded two novae, over 250 new variable stars, and light curves for 1,300 variables.

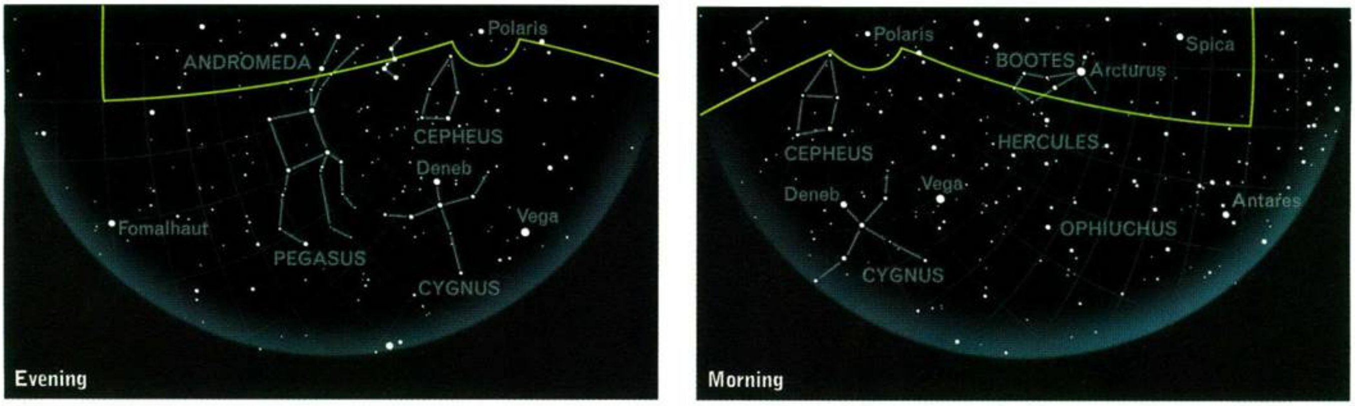
A series of sketches like this one can help determine if a suspected comet is moving. Shigeki Murakami



Night of a Lifetime

Some comet hunters find success only after a lifetime of effort. Patrick Stonehouse had searched in vain for comets for several hundred hours over 30 years. Then, on April 22, 1998, he struck ice.

Beginning his first comet sweep of the night with his 17.5-inch scope, Stonehouse immediately noticed a suspicious object. Over 20 minutes, the object moved northwest. The next two nights were clear; the comet was confirmed on April 25 and named C/1998 H1 (Stonehouse). Stonehouse fondly recalls those intervening days as filled with both sleep deprivation and excitement.



Evade the professional surveys by searching beyond their range (below lines above). For observers at mid-northern latitudes this month, use the maps above as a guide in the evening (left) and morning (right). *Astronomy:* Roen Kelly

Today Stonehouse sweeps for comets with a 25-inch telescope. He hopes to find another comet or asteroid, but if not, he says, "I see a multitude of diverse and magnificent heavenly objects during every search, so I am always happy in the searching and never feel disappointed for not having found anything new."

Doug Snyder of Palominas, Arizona, shares Stonehouse's view. While his goal is to discover a comet, he's in it for the enjoyment. "I find myself searching areas in which the likelihood of finding one is very remote, just for the pleasure of viewing areas of the sky that I would not normally explore," says Snyder. His casual method worked on March 11, 2002. While moving his 20-inch scope around Aquila, he found a faint patch of light that proved to be a new comet. His was the first visual comet discovery in the United States since Stonehouse's four years earlier. "It's a celestial jungle out there," says Snyder.

Shigeki Murakami, of Niigata, Japan, had given up hope of finding his prey in that jungle. Heartened by the 2002 comet discovery by his compatriot Kaoru Ikeya, Murakami decided to resume his comet searches with a self-built 18-inch. His persistence paid off. Just hours after Snyder's sighting, Murakami saw the same comet and it became Comet Snyder-Murakami.

In the past two decades, the most prolific comet discoverers have been David Levy, Bradfield, and Machholz. With three discoveries in the last five years, Syougo Utsunomiya is the most successful comet hunter in recent times. He found his latest comet only one week after Snyder and Murakami found theirs. A farmer in rural Kumamoto, Japan, Utsunomiya scans the sky with 25x150mm binoculars for an hour each dusk and dawn. He searches near the Sun and the southern horizon in an attempt to evade the surveys. Encoders on his mounting indicate coordinates and help indentify deep-sky objects.

Meanwhile, Don Machholz continues his observing sessions in northern California. He has amassed nearly 7,000 hours at the eyepiece since he began the pursuit in 1975.

Machholz notes that almost all of his nine comets were discovered in the zone of low elongation from the Sun, which most surveys avoid. During the first quarter of 2002, amateurs discovered three comets there.

Comet hunting is alive and well despite the competition from the robots. While a satisfying feeling of accomplishment is common among those who have been fortunate enough to make a discovery, remember — comets or no comets — gaining an intimate knowledge of the sky can be gratifying. And you never know — if you keep looking, there might be a comet out there with your name on it. ▣

Tom Polakis is an aerospace engineer in Tempe, Arizona. An avid observer, he writes Astronomy's *Celestial Portraits column.*

Your Name Here

Is that a comet?

Charles Messier wasn't the only one to notice that there are plenty of astronomical objects posing as comets. Globular clusters, distant galaxies, and even small groups of stars have been mistakenly reported as new comet discoveries. In fact, false alarms today outnumber true claims by five to one.

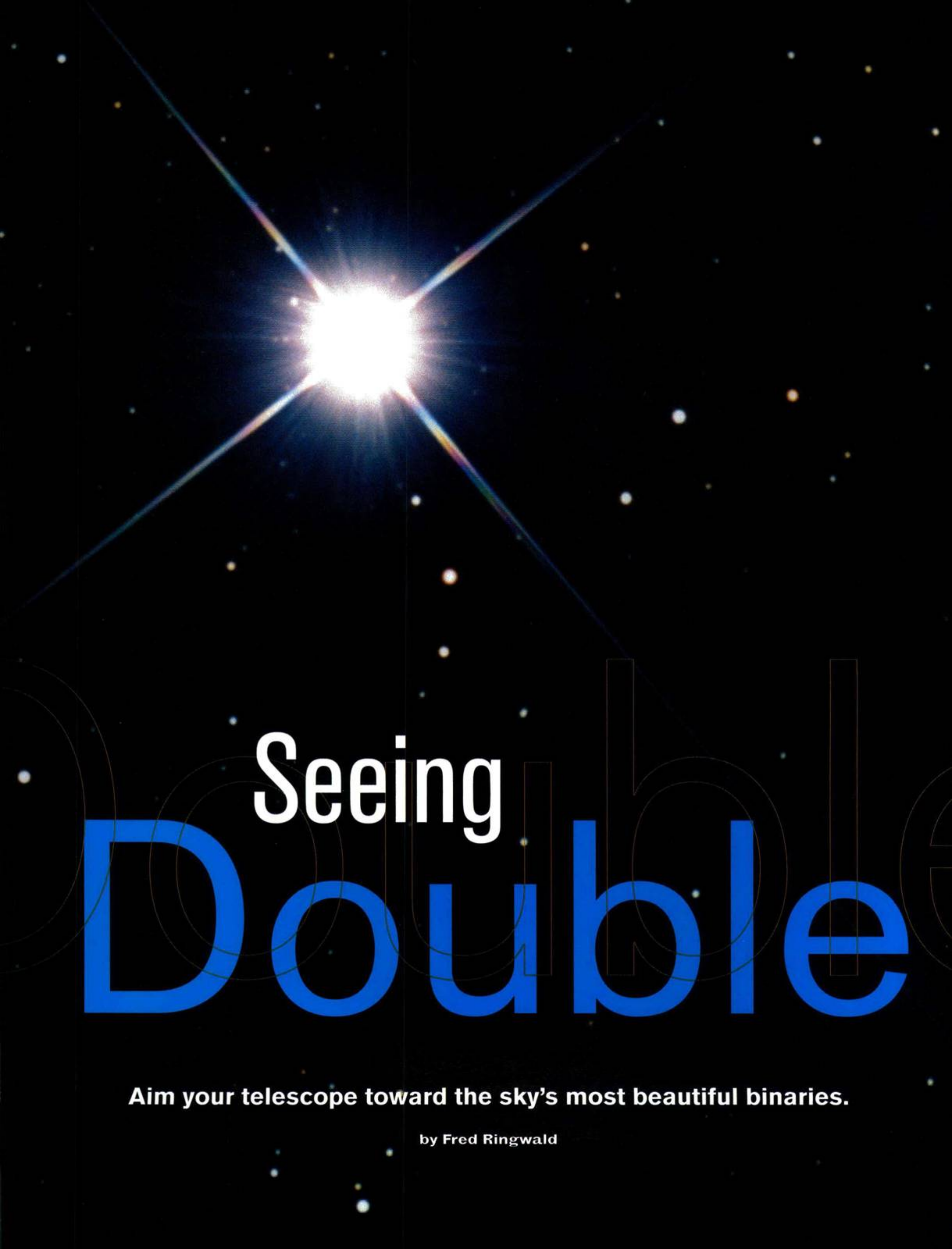
Before you damage your reputation with a false report, get to know what comets look like. Most comets are discovered around magnitude 10. Seeking out similar, known objects will give you an idea of what to expect. If you think you're onto a comet, first check a detailed star atlas such as *Uranometria 2000.0*. If your suspect isn't plotted there, that's a good sign. Next, watch for motion, which should be detectable at a magnification of 150x or so within a half-hour.

If it is moving, it may well be a comet. It just may not be a new comet. Bring a current list of comet locations (ephemerides) out to the field to ensure you haven't rediscovered a cataloged comet. Find comet positions and other helpful tips at NASA's Comet Observation Home Page at http://encke.jpl.nasa.gov.

Eureka! Now what do I do?

Make a note of your comet's position by plotting it on a large-scale star atlas. Make an eyepiece drawing, and another one in its new position a half-hour later. Record the direction and rate of motion. Refine those coordinates to within an arcminute of accuracy. Record the times of your observations. Detailed descriptions of the appearance of the comet are also helpful.

Next, you'll want to communicate your discovery to the Central Bureau for Astronomical Telegrams. For further details, check out the website at http://cfa-www.harvard.edu/iau/CometDiscovery.html. — *T. P.*



Seeing Double

Aim your telescope toward the sky's most beautiful binaries.

by Fred Ringwald

Anywhere you look in a clear, dark sky, most of the stars you see aren't the lone cosmic lamps they appear to be. Telescopes reveal what the eye cannot see — more than half the stars in the Milky Way are members of tight-knit pairs called binaries.

Some stellar pairings are counterfeit binaries. These "optical doubles" are coincidences, because their members are light-years apart but lie along the same line of sight so they appear next to each other. But true binaries (also called physical double stars) orbit a common center of mass and are bound together by their gravity.

When observing stellar pairs, sometimes the fainter of the two, dubbed the "secondary" (or star B), is much dimmer than the other, the "primary" (star A), making it hard to see. If, on the other hand, both stars are comparable in brightness and are far enough apart, an observer usually can see both stars distinctly. Those systems that can be resolved into individual stars are called visual binaries.

Binary and other multiple stars are important to astrophysics, as everything we know about stellar masses comes from observing them and measuring their orbits. In a way, all we know about stellar evolution comes from observing binary stars. Many binaries are good for student and public outreach observing, too, because they are so striking.

Some observers have difficulty discerning colors in solitary stars. With binaries, however, colors are frequently obvious because of the contrast between the members. Many novice observers are surprised to see these colors, because the unaided eye doesn't receive enough light to perceive them. For advanced observers, the color helps to reveal a star's character.

What would the sky look like from the surface of a planet in one of these systems? We now know that planets can

Sirius, the brightest star in the night sky, is a binary. However, the primary member, Sirius A, easily outshines its companion white dwarf, which makes it difficult to spot Sirius B without a telescope. John Chumack

Suggested Targets for Seeing Double

Beta Tucanae
0h31m32.7s, –62°57'30"
Va = 4.3, B9V; Vb = 4.1, A2V+
P.A. = 169°; Separation = 27.1" = 1,200 AU
P fixed; Distance = 140 light-years
Each component is double:
beta1: Va = 4.4, A0.5; Vb = 13.5, spectral type unknown, A1V; P.A. = 151°; Separation = 2.4" = 100 AU; P fixed
beta2: Va = 4.8, A2V; Vb = 6.0, spectral type unknown; P.A. = 276°; Separation = 0.5" = 20 AU; P = 44 years

55 Piscium
0h39m55.6s, +21°26'19"
Va = 5.4, K0Iab; Vb = 8.7, F3V
P.A. = 194°; Separation = 6.6" = 830 AU
P fixed; Distance = 410 light-years
Orange and blue, "nice colors" (Burnham)

Gamma Arietis
1h53m31.8s, +19°17'38"
Va = 4.6, A1p; Vb = 4.7, B9V
P.A. = 0°; Separation = 7.8" = 480 AU
P long (slowly closing); Distance = 200 light-years
Both white, look alike; "beautiful ... very easy" (Norton)

Gamma Andromedae
2h03m54.0s, +42°19'47"
Va = 2.3, K2II; Vb = 4.8, B8V
P.A. = 63°; Separation = 9.8" = 1,100 AU
P long (little change); Distance = 350 light-years
Orange and blue; "superb" (Norton); B is also double:
Vc = 6.3; P.A. = 103°; Separation = 0.4" = 40 AU; P = 61 years

66 Ceti
2h12m47.5s, –02°23'37"
Va = 5.7, F8V; Vb = 7.7, G4
P.A. = 234°; Separation = 16.5" = 760 AU
P unknown (slow); Distance = 150 light-years
Yellow and blue; "fine pair" (Norton)

Iota Cassiopeiae
2h29m04.0s, +67°24'09"
Va = 4.6, A5p; Vb = 6.9, F5
P.A. = 230°; Separation = 2.5" = 120 AU
P(AB) = 840 years; Distance = 160 light-years
Triple: Vc = 8.4, G4; P.A. = 114°; Separation = 7.2" = 350 AU
"Fine object in 10 cm" (Norton); yellow, blue, and blue (illusion?)

Polaris
2h31m49.1s, +89°15'51"
Va = 2.0 (variable), F7:Ib-IIvar; Vb = 8.2, F1
P.A. = 218°; Separation = 18.4"
No P because unbound;
Distance to A = 430 light-years
An optical double with two other faint stars within 1'; A is a Cepheid variable

Theta Eridani
2h58m16.4s, –40°18'17"
Va = 3.2, A4III; Vb = 4.3, A1V
P.A. = 88°; Separation = 4.5" = 170 AU
P long; Distance = 120 light-years
Both white; "fine pair" (Norton)

Rigel
5h14m32.3s, –08°12'06"
Va = 0.1, B8Iab; Vb = 10.4, B9V
P.A. = 202°; Separation = 9.5" = 2,200 AU
P unknown (fixed); Distance = 770 light-years
Blue-white supergiant with main-sequence companion

Lambda Orionis
5h32m00.4s, –00°17'57"
Va = 3.6, O9.5II; Vb = 5.5, B2V
P.A. = 43°; Separation = 4.4" = 1,200 AU
P unknown (fixed); Distance = 900 light-years
The head of Orion; "very fine region" (Norton); "elegant" (Burnham)

Sigma Orionis
5h38m44.8s, –02°36'00"
Va = 4.0, O9.5V; Vb = 6.0, B0.5V
P.A. = 115°; Separation = 0.2" = 80 AU
P = 170 years; Distance = 1,200 light-years
AB binary is blue and red (by contrast); also three faint components, with triple S761 in same field; "fine telescopic object" (Norton)

Double star imges by Jack Newton, except Castor (page 80) by John Chumack form and exist in binary star systems; the first such planet was discovered in 1999 by David Bennett and Sun Hong Rhie. This makes it all the more interesting for casual observers to look at binary stars, think about their contribution to our understanding of the universe, and wonder what else might be there, unseen.

The accompanying list of stars are good telescope targets. *Norton's Star Atlas* and other publications list more binary systems, but many are faint or too closely spaced to resolve clearly. Only the best-looking systems are included here; this may mean clearly resolvable yet not too widely separated. They may be colorful, attended by faint companions, or otherwise visually interesting.

All coordinates are the Epoch 2000 positions of the primary stars. Following the coordinates are Va and Vb, the visual magnitudes of stars A and B, respectively. After each magnitude is the spectral type of that star. Spectral type, briefly, is the color the star will have, depending on its temperature. The hottest stars, types O and B, are blue; A stars are white; F stars are whitish-yellow; G stars (like the Sun) are yellow; K stars are orange; and M stars (the coolest) are red.

How the eye perceives color is tricky, especially in low light, in which it becomes color-blind. A bright star viewed through a large telescope can deliver enough light to activate one's color vision, but color perception also depends greatly on contrast. Many stars in binaries appear green because of contrast effects, usually because the green-looking star is really blue while its partner is reddish. Sometimes these effects are unpredictable and vary from observer to observer.

Listed after magnitudes and spectral types are position angles and separations between the stars, all for Epoch 2000. Position angles, listed as P.A., are in degrees. A position angle is the angle from north through star A to star B, measured from 0 to 360° in the eastward direction. In other words, if star B is due north of star A, P.A. = 0°; if star B is due east of star A, P.A. = 90°.

Separations between the stars are measured in arcseconds. Visual doubles are useful for checking the seeing, or how much the turbulence in Earth's atmosphere affects how clearly an observer can see. In 1.0" seeing or better, characteristic of superb conditions, one can resolve stars 1.0" (or farther) apart. In 3.0" to 4.0" seeing, more typical of backyard viewing, one can resolve stars at least

Beta Monocerotis
6h28m49.1s, –07°01'59"
Va = 4.6, B3Ve; Vb = 5.4, B3ne; Vc = 5.6, B3e
P.A. = 132°; Separation = 7.3" = 1,600 AU
P unknown (fixed); Distance = 700 light-years
"Fine fixed triple" (Norton); "fine triple star" (Burnham); BC make up fainter component:
P.A. = 106°; Separation = 2.6"

Sirius
6h45m08.9s, –16°42'58"
Va = –1.47, A1V; Vb = 8.44, DA
P.A. = 150°, Separation = 4.6" = 12 AU
P = 50 years; Distance = 8.6 light-years
Difficult! Close together and A is so much brighter than B, a white dwarf; worth it just to gaze at Sirius A

Castor
7h34m35.9s, +31°53'18"
Va = 1.6, A1V; Vb = 1.6, A2Vm
P.A. = 65°; Separation = 3.9" = 62 AU
P = 470 years; Distance = 52 light-years
Both bright, nearly identical, and close together; also triple companion, YY Gem:
Vc = 8.9-9.6 (variable), M0.5V; P.A. = 163°; Separation = 70"; P fixed

k Puppis
7h38m49.4s, –26°48'06"
Va = 4.5, B6V; Vb = 4.6, B5IVn
P.A. = 318°; Separation = 9.9" = 1,400 AU
P unknown (fixed); Distance = 450 light-years
Striking, nearly equal in brightness

Gamma Velorum
8h09m32.0s, –47°20'12"
Va = 1.8, WC; Vb = 4.2, B1IV
P.A. = 220°; Separation = 41.2" = 0.17 light-years
P unknown (fixed); Distance = 840 light-years
A is a Wolf-Rayet star, losing its atmosphere in a fierce wind; B is a hot, luminous, main-sequence star

Regulus
10h08m22.3s, +11°58'02"
Va = 1.4, B7V; Vb = 8.1, K2V
P.A. = 307°; Separation = 177" = 4,200 AU
P unknown (fixed); Distance = 78 light-years
Bright, blue star with faint, orange companion, but "easy" (Burnham)

Gamma Leonis
10h19m58.4s, +19°50'29"
Va = 2.6, K1IIIb; Vb = 3.5, G7III
P.A. = 125°; Separation = 4.4" = 230 AU
P = 620 years; Distance = 170 light-years
"Fine pair" (Norton); "one of the finest" (Burnham)

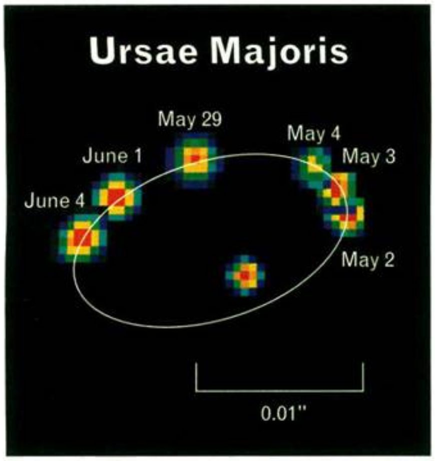
Acrux (Alpha Crucis)
12h26m35.9s, –63°05'57"
Va = 1.4, B0.5IV; Vb = 2.09, B1V
P.A. = 115°; Separation = 4.7" = 460 AU
P unknown (little change); Distance = 320 light-years
Also visual (unbound) field star: V = 4.78, B4IV; Separation = 126"

Gamma Virginis
12h41m39.6s, –01°26'58"
Va = 3.7, F0V; Vb = 3.6, F0V
P.A. = 259°; Separation = 1.5" = 18 AU
P = 169 years; Distance = 39 light-years
"One of the finest of the visual binaries" (Burnham), though moving closer together

Mizar
13h23m55.2s, +54°55'25"
Va = 2.3, A2V; Vb = 4.0, A1m
P.A. = 152°; Separation = 14.4" = 350 AU
P long (little change); Distance = 78 light-years
Both blue-white

Mizar and Alcor
13h25m13.5s, +54°59'17"
Va = 2.1, A2V; Vb = 4.0, A5V
P.A. = 71°; Separation = 708.7" = 0.25 light-years
P fixed; Distance = 78 light-years
Unaided-eye double

Alpha Centauri
14h39m36.2s, –60°50'08"
Va = –0.1, G2V; Vb = 1.3, K1V
P.A. = 222°; Separation = 14.1" = 19 AU
P = 80 years; Distance = 4.39 light-years
Yellow and white, "superb" (Norton); the closest star system to our solar system; easy and colorful; Proxima Centauri (Vc = 11.05, M5.5Ve) is over 2° (0.2 light-years) away from Alpha and may not be bound



Mizar, the middle star in the handle of the Big Dipper, is a binary. Both stars, Mizar A and B, are binaries, but most telescopes cannot resolve all four of Mizar's stars. In this mosaic of six images taken in 1996, the Navy Prototype Optical Interferometer (NPOI) in Arizona reveals the orbital motion of Mizar A's companion. J. Benson et al., NPOI Group, USNO, NRL

3.0" to 4.0" apart.

The separations are also given in astronomical units, or AU, all of which were calculated by the author, using the stars' distances from Earth. These are only minimum distances, as they are projected separations — often, we don't know a system's 3-dimensional geometry — but they are interesting for the imagination. For perspective, the average distance from the Sun to Pluto is about 40 AU, the average Sun-Earth distance is 1 AU, and the average Sun-Jupiter distance is 5.2 AU (63,270 AU = 1 light-year).

P is the orbital period of the system in years. Some stars noticeably shift in relation to each other with time, and there's value in having amateur observers measure, record, and report these changes. Eyepiece observers can use special instruments, called filar micrometers, to measure stars' relative positions. CCD users can use Herbert Raab's shareware program for PCs called *Astrometrica*. Good places to report your observations are *The Double Star Observer*, a journal for amateurs and professionals dedicated to double star observing, and the Webb Society Double Star Section (see "Resources").

"Fixed" means no orbital motion has been seen. Such systems, if bound, often have orbital periods of centuries. Pairs with common proper motion ("c.p.m.") show no obvious orbital motion but move together through the galaxy, and so are probably bound.

Nu Scorpii

16h11m59.7s, –19°27'39"
Va = 4.1, B2IV; Vb = 6.3, B8/B9V
P.A. = 337°; Separation = 41.1" = 5,600 AU
P fixed; Distance = 440 light-years
Another double double: the sting at the tail of the Scorpion
nu1: Va = 4.1, B2IV; Vb = 6.9, B9p
P.A. = 3°, Separation = 0.9" = 120 AU, fixed
nu2: Vc = 6.6, B8V; Vd = 7.6, B9Vp
P.A. = 51°, Separation = 2.3" = 300 AU, widening

Antares

16h29m24.2s, –26°25'55"
Va = 1.1 (variable), M1.5Ib; Vb = 5.4, B2.5V
P.A. = 273°; Separation = 2.6" = 500 AU
P = 900 years; Distance = 600 light-years
Difficult because A, a red supergiant, is much brighter than its blue companion, which appears green by contrast

Alpha Herculis

17h14m38.9s, +14°23'25"
Va = 3.1-3.4 (variable), M5Ib-II; Vb = 5.4, G5III
P.A. = 104°; Separation = 4.6" = 500 AU
P = 3,600 years; Distance = 380 light-years
Red and green; "one of the finest colored double stars" (Burnham)

Epsilon Lyrae

18h44m20.4s, +39°40'12"
Va = 4.7; Vb = 4.5
P.A. = 173°; Separation = 207.7" = 0.2 light-years
P = unknown (fixed); Distance = 200 light-years
The famed "double double"; both components are close visual binaries:
eps1: Va = 5.1, A4V; Vb = 6.0, F1V;
P.A. = 350°; Separation = 2.6" = 160 AU; P = 1,200 years
eps2: Va = 5.1, A8Vn; Vb = 5.4, F0Vn;
P.A. = 82°; Separation = 2.3" = 140 AU; P = 600 years

Theta Serpentis

18h56m14.6s, +04°12'08"
Va = 4.6, A5V; Vb = 5.0, A5Vn
P.A. = 104°; Separation = 22.3" = 1,000 AU
P fixed; Distance = 140 light-years
"Fine, easy" (Norton)

Albireo (Beta Cygni)

19h30m43.3s, +27°57'35"
Va = 3.1, K3II+; Vb = 5.1, B8Ve
P.A. = 54°; Separation = 34.4" = 4,000 AU
No P because unbound;
Distance (A) = 400 light-years
Gold and blue; an optical double — the blue star is about twice as far away as the gold one — but "glorious" (Norton); among the best in the sky

Alpha Capricorni

20h17m38.9s, –12°30'30"
Va = 4.2; Vb = 3.6
P.A. = 29°; Separation = 378"
No P because unbound; Distances = 700 (alpha1) and 110 (alpha2) light-years
Unaided-eye, optical double; each component multiple:
alpha1: Va = 4.2, G3Ib; Vb = 9.6, spectral type unknown; P.A. = 221°, Separation = 45.4" = 1,000 AU
alpha2: Va = 3.6, G6/G8III; Vb = 10.6, spectral type unknown; P.A. = 172°, Separation = 6.6" = 220 AU

Gamma Delphini

20h46m39.5s, +16°07'28"
Va = 4.3, K1IV; Vb = 5.1, F7V
P.A. = 268°; Separation = 9.6" = 300 AU
P long (slow); Distance = 100 light-years
Pleasing to show after Albireo; its colors are a muted lemon and lime-green, in contrast to Albireo's garish gold and blue

Delta Cephei

22h29m10.3s, +58°24'54"
Va = 4.1, F5Iab; Vb = 6.3, A0
P.A. = 191°; Separation = 41.0" = 0.2 light-years
P long, c.p.m.; Distance = 1,000 light-years
Yellow and blue; A is a variable, the prototype of Cepheid variables, which pulsate; also a faint triple companion: Vc = 13.0

Definitions

All the stars in this list are double stars, but astronomers use these terms to describe different types of doubles.

binary star: two stars that orbit a common center of mass

visual binary: a binary star that can be visually separated with a telescope, binoculars, or the naked eye

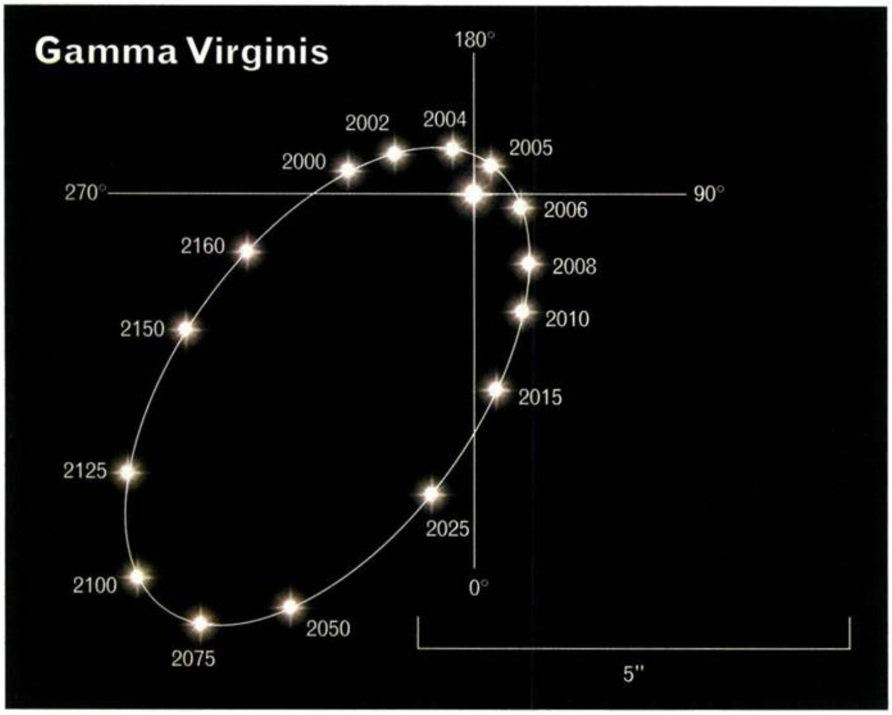
double star: two stars that appear close, either because they orbit a common center of mass or because they lie along the same line of sight

optical double star: two stars that appear close but are not orbiting a common center of mass

physical double star: two stars that can be visually separated and are orbiting a common center of mass (same as a visual binary)

Resources

- Astronomical League Double Star Observing Club http://www.astroleague.org/al/obsclubs/dblstar/dblstar1.html
- *Burnham's Celestial Handbook*, by Robert Burnham, Jr. (Dover, 1978)
- *Dr. Thorstensen's Cycle of Celestial Sights*, unpublished list by Prof. J. R. Thorstensen, Dartmouth College, 1991
- *The Double Star Observer* http://home.cshore.com/rfroyce/dso
- "Leading a Double Life," article by Sissy Haas in *Sky & Telescope's Skywatch 2000*, p. 95
- *Norton's Star Atlas and Reference Handbook*, 19th ed., 1998, ed. by Ian Ridpath
- *The Pocket Guide to Astronomy*, by Patrick Moore (Simon and Schuster, 1980)
- SIMBAD Astronomical Database, operated at CDS, Strasbourg, France http://simbad.u-strasbg.fr/Simbad
- *Webb Society Deep-Sky Observer's Handbook, Volume 1: Double Stars*, 2nd ed., compiled by the Webb Society, K. G. Jones, editor (Enslow, 1986)
- Webb Society Double Star Section http://www.webbsociety.freeserve.co.uk/notes/doublest01.html



Located 39 light-years from Earth, Gamma Virginis is a binary composed of two stars nearly identical in brightness. It takes about 169 years for the secondary to complete one orbit around the primary, and the two are currently drawing closer to one another. Roen Kelly

Distances are given in light-years, not parsecs. Amateur astronomers and the public often prefer this measurement, because they can appreciate that the light we see from a star 400 light-years away is 400 years old. If others don't know this, tell them; they are often fascinated. All distances listed are from trigonometric parallaxes, most measured by the European Space Agency's astrometry spacecraft Hipparcos.

The selection of this group was subjective. The list favors colorful systems, multiple systems, those that are bright and easily resolvable but not too wide, and pairs containing one very bright star and a fainter companion.

Most are binaries, but many have even more members upon closer examination. There are a few optical doubles thrown into the mix as well. Unaided-eye doubles are perhaps under-represented because typically, they are not much to look at through a telescope. Still, in addition to Mizar and Alcor, several others around the sky include Alpha Capricorni, Epsilon Lyrae (for observers with keen eyesight), and Mu Scorpii (not listed here).

Once you finish with this list, I suggest trying the Astronomical League's list of "100 of the finest double and multiple stars in the heavens."

Double stars can be a surprise and a delight when viewed through a telescope eyepiece. Even close pairs that are just plain white often elicit "wows!" of amazement. Many stars have been left off this list, but those included will most easily infect you with the binary bug.

Fred Ringwald studies binary stars with the Hubble Space Telescope from his office at the Department of Physics at California State University, Fresno.

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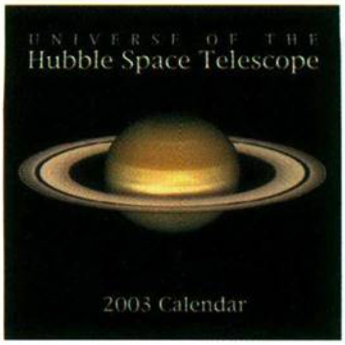
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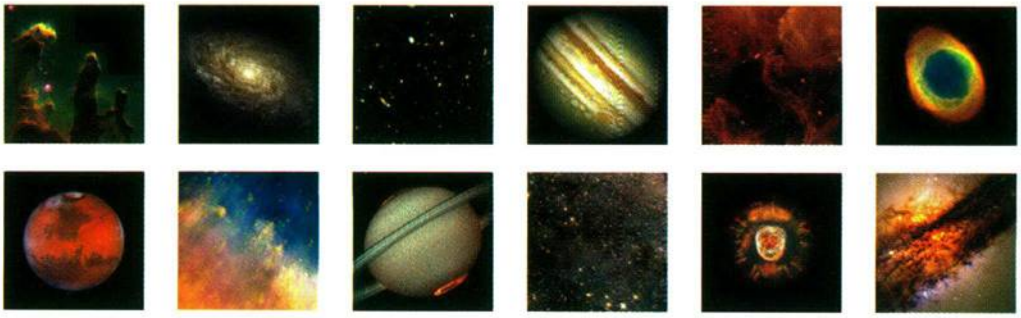

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Going Global

No matter where you go, the Celestron NexStar 8 GPS finds its way to the stars.

Text by Phil Harrington
Photos by Bill Zuback

Left: Using GPS technology, this NexStar will take you on an automated tour of the sky.

Right: Celestron provides a 9x50 finder scope with this 8-inch SCT.

WHETHER ON A HIKE THROUGH THE WOODS, ON A cross-country road trip, or out for a night of remote stargazing, it's getting harder and harder to get lost these days.

Thanks to a digital constellation of two dozen high-tech, military satellites, and readily available hand-held devices no bigger than telephones, people with the right equipment can determine their positions on the planet within a few feet. Global Positioning System (GPS) technology is found everywhere, from automated maps to automobiles.

In 2001, Celestron introduced yet another exciting application of GPS technology, the first self-activating Go-to telescope. The 8-inch f/10 NexStar 8 GPS (reviewed here) and 11-inch f/10 NexStar 11 GPS Schmidt-Cassegrains combine the ability of the NexStar's Go-to computerized aiming system with GPS technology.

Like the standard NexStar 8, the GPS version's computerized database features more than 40,000 sky objects, including solar system objects, double stars, and variable stars, as well as deep-sky objects from the Messier, NGC, IC, and many lesser-known catalogs. Unlike the single-armed standard NexStar, however, the 8-inch GPS includes a two-pronged fork mount, adding an extra degree of stability.

But the most amazing feature is the telescope's ability to "find" itself. The user needs only to attach the telescope and fork mount to its tripod, plug it in, and flip a switch. The telescope then comes to life, automatically linking to the GPS satellite system to determine the exact time, date, and its location. Once that information has been determined and stored (a process that takes about a minute), the NexStar GPS automatically moves to two alignment stars, pausing each time to ask the user to center the star in the field of view. And that's it – the telescope is ready to hunt for celestial gems.

{No Ordinary Schmidt-Cassegrain}

The promise of this combination was enticing, but could Celestron actually deliver a telescope that practically sets itself up? To find out, I put one of the 8-inch NexStar GPS telescopes through its paces, taking a critical look at its optical and mechanical performance.

Included with Celestron's shipment were the telescope, fork mount assembly, and the standard accessories, including a 40mm Plössl eyepiece, 1.25" star diagonal, 9x50 finderscope, three vibration suppression pads, hand controller, and AC adapter to power the built-in computer control.

Right out of the box, it quickly became apparent that this was no ordinary Schmidt-Cassegrain. The real value of carbon fiber is its thermal properties. For optimal telescope performance, the optics temperature must match that of the outside air. Telescope optics, transferred from indoors to a cooler outdoor environment, often take an hour or more to achieve thermal equilibrium. A traditional metal tube, a great absorber of heat, slows the process. Carbon fiber, on the other hand, does not absorb heat as readily, shortening up the cool-down process. The carbon-fiber tube also lessens focus shift as the telescope cools during the night – an important consideration for long-exposure astrophotos and CCD imaging.

Recognizing that carbon fiber would flex too much if the tube were connected directly to the fork arms, Celestron secures the tube to the mount using two exo-skeletal beams mounted between the front and back metal framing rings.

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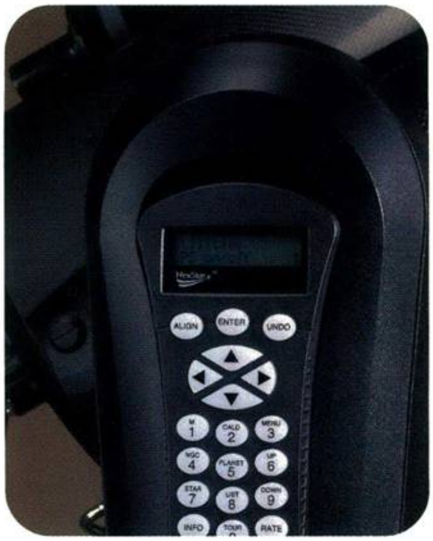
AUTO GUIDE
AUX 2
NexStar

Celestron's sturdy fork mount attached to a heavy-duty tripod will keep scope vibrations at a minimum.



Using the hand-control in unison with the Global Positioning System simplifies the alignment process.

{Snappy Set Up}

Like nearly all Schmidt-Cassegrain telescopes sold in the past three decades, the NexStar GPS's optical tube assembly and fork equatorial mount and base are inseparably joined at the factory to form a single unit. I found the initial setup to be pretty straightforward. First, I assembled the Celestron heavy-duty tripod. Each tripod foot has a rubber bumper to absorb vibrations. While the bumpers help, I recommend removing them and placing the included vibration-suppression pads under each tip instead. Doing a "rap test" by hitting a fork arm with the open palm of my hand, I found that the mounting dampens vibrations in less than three seconds. This impressive performance ranks as the steadiest fork mount I have ever tested.

A single alignment pin that protrudes from the tripod lines up with a center hole on the bottom of the fork mount to aid with positioning the telescope on the mount. I found it challenging to line up the pin with its mating hole at first, especially in the dark, although the chore eventually got easier with practice. Once the pieces were in place, I bolted the mount to the tripod using three cap screws supplied by Celestron. I also found these difficult to work with in the dark and would recommend replacing them with three thumbscrews.

After quick installment of the finder scope and connection of the 110-volt AC power cord (a 12-volt DC power cable with a car cigarette lighter plug is sold separately), I was ready to start the initialization process.

{Automatic Alignment}

Several procedures are available for initializing the NexStar GPS's electronic brain for a night out, although most users will select the "GPS Align" mode. Pressing the "ENTER" button on the hand controller will cause the telescope to begin moving to its north and level position, a process that takes a minute or so. The hand-control readout displays "Searching" as the onboard computer establishes a link to GPS satellites and records the time, date, and location data. Once set, the telescope automatically slews to the first of two alignment stars. When the telescope stops, the readout tells the user to center the star in the finder scope using the controller's up-down/left-right arrows. Once the star is centered, you simply have to repeat the centering process by viewing through the telescope's eyepiece, and pressing "Align" when done. After completing the process for a second star, the telescope is ready to use.

The NexStar GPS's electronic compass is based on magnetic north, not true north. Depending on where you are, that angular difference, called magnetic declination, can be significant. (The magnetic north pole is currently located near Ellef Ringnes Island in northern Canada and is moving, on average, between 10 to 40 meters northward each year.) Although the telescope's software is designed to compensate for magnetic declination, the instrument's initial aim at the two alignment stars was still off by about 15° to 20°.

I found the telescope's initial aiming accuracy can be greatly improved by selecting the "Utilities" menu on the hand controller, then choosing "Calibrate North" after successfully completing a GPS alignment. Calibrate North compensates for magnetic declination, and then automatically retains that information for future observing. Once Calibrate North is set, the telescope will aim to within a degree or two of the alignment stars when first turned on. The manual mentions this important point only in passing, however. If I hadn't spoken with Celestron's Vice President of Engineering and Manufacturing Rick Hedrick, I wouldn't have even noticed this feature.

Four arrows on the hand controller can be used to properly align the telescope with the selected star. I was impressed at how the telescope automatically changed its rate of motion during the two-step alignment process, moving more quickly during coarse alignment through the finder than during fine alignment through the telescope itself. The telescope's rate can also be changed manually, anywhere from 0.5 times sidereal rate (useful for astrophotography) to a zippy 3° per second.

Of the other polar-alignment methods, "Auto-Align," "Two-star Alignment," and "Quick-Align" are useful when observing from a location where a link to GPS satellites is difficult to establish. The fourth method, "EQ North/EQ South Alignment," is useful when manually polar aligning the telescope on an equatorial wedge.

As with all Go-to telescopes, you'll need a wedge to take long-exposure photographs through the NexStar. While the computerized drive in the NexStar GPS will follow the stars flawlessly, it does so in a step-like, up-down/left-right motion. The sky, however, moves in a single, arcing motion, causing the

NexStar's field of view to rotate around its center, which would ruin long exposures of faint targets. The wedge (sold separately and not tested in this review) is required to tilt the telescope's polar axis at an angle matching the observer's latitude, thereby letting the telescope track the stars with the same fluid motion. Using the equatorial wedge also requires that the telescope be polar-aligned the old-fashioned way – manually.

{Performance}

With the telescope set up and the Go-to system approaching, I began with Jupiter and Saturn, which were setting in the west. Both focused nicely, revealing some very sharp detail in the jovian clouds and saturnian rings. Next, I let the telescope do the driving over to M42 in Orion, where the NexStar GPS's Starbright-coated optics easily resolved the four stars of the Trapezium. I could also just barely make out one of the two fainter stars that is set among the brighter four, a good test for an 8-inch set of optics. Onward and upward, I next paused to enjoy four of winter's open clusters, M35, M36, M37, and M38. The included 40mm Plössl eyepiece showed all four as sharp collections of stars gathered together in tight swarms. Later in the evening, I swung into the spring sky, traveling effortlessly from galaxy to galaxy, each time finding my quarry set at or near the field's center.

Throughout my observations with the NexStar 8, I was pleased with the image quality. Optical collimation was close to perfect right out of the box, indicative of Celestron's product inspection and packing ability. If the telescope needed attention, however, an observer would turn one or more of the adjustment screws on the secondary-mirror assembly. The instruction manual includes a good description of this procedure, as well as other important topics, such as telescope set-up and care, use of the hand controller, and even a primer on observing and astrophotography.

To focus the image, the primary mirror in the NexStar, like all Celestron (and Meade) Schmidt-Cassegrain telescopes, moves back and forth along an internal track. As the mirror slides, it can shift or tilt, causing images to jump. Today's Schmidt-Cassegrain telescopes show much less image shift than those made two or three decades ago, and this NexStar 8 was no exception. Indeed, there was no image shift seen at all, even at 290x. In addition, the focusing knob had just the right amount of tension, allowing it to turn evenly and smoothly.

Performing the star test proved that the optics were top quality. Images both inside and outside of focus were identical and nearly textbook perfect, proving that these optics were among the finest I had ever seen in a Schmidt-Cassegrain telescope. I could only detect the slightest hint of spherical aberration. Astigmatism and other telltale optical imperfections were imperceptible.

I was impressed by the accuracy of the NexStar GPS's Go-to system. Even when moving from one direction to the opposite part of the sky, the telescope placed each selected object very near the center of a 7mm eyepiece (290x) without fail. This is one of the best performances of a Go-to system I have witnessed. Tracking accuracy was also good for visual observations, thanks to the telescope's well-designed worm-gear clock drive. The drive tracked the stars accurately, with selected targets staying in view for an hour without need for adjustment. The drive systems in earlier NexStar models sounded like a swarm of buzzing bees, but this Celestron telescope was pleasantly quiet when tracking the sky. Even when moving full speed across the sky toward a selected target, the NexStar 8 generated only a faint hum.

{Specifications}

Aperture: 8"

Focal length: 2,000mm

Focal ratio: 10

Secondary mirror Obstruction: 2.7" (11% by area)

Optical tube length: 21"

Telescope and mount weight: 67 lbs.

Mount: Fork arm mount on heavy-duty adjustable tripod

Accessories: 40mm Plössl, 1.25" star diagonal, 9x50 finderscope, vibration-suppression pads, hand controller, AC adapter

Typical "street price": $2,495

{Contact information}

Celestron International
2835 Columbia Street, Torrance, CA 90503
Phone: 310–328–9560
www.celestron.com

All telescope drives, however, have an inherent fault called "periodic error," which causes the instrument's aim to deviate on a regular, predictable basis. For astrophotographers, where tracking accuracy must be spot-on, the Celestron worm-gear drive also features a periodic error correction (PEC) control that the user can program to correct for recurrent wobbles. After the observer initializes the PEC's memory circuit by switching to the "Record" mode in the menu, the telescope is guided manually using the controller's arrows to keep a star centered in the eyepiece. Once the recording session is completed (typically, an eight-minute process), the circuit plays back the corrections to compensate automatically for any worm-gear periodicity. The NexStar PEC recording feature is permanent, in that once the periodic error correction is set, the instructions will be remembered by the scope for subsequent use.

{Good, Old-Fashioned Fun}

Like other worm-driven Celestron Schmidt-Cassegrains, the NexStar 8 GPS also comes with a Fastar secondary mirror assembly, designed specifically to couple with the ST-237 CCD imaging system manufactured by Santa Barbara Instrument Group (SBIG). While all Fastar-enabled instruments can also be used for visual observations as well as conventional astrophotography, this unique design holds the CCD imager in front of the telescope in place of the secondary mirror, reducing the system's effective focal ratio to an amazing f/1.95. This, coupled with the tremendous light-recording ability of a CCD imager, creates an optical system that can capture images of faint objects in a matter of seconds, rather than the minutes or even hours of conventional film.

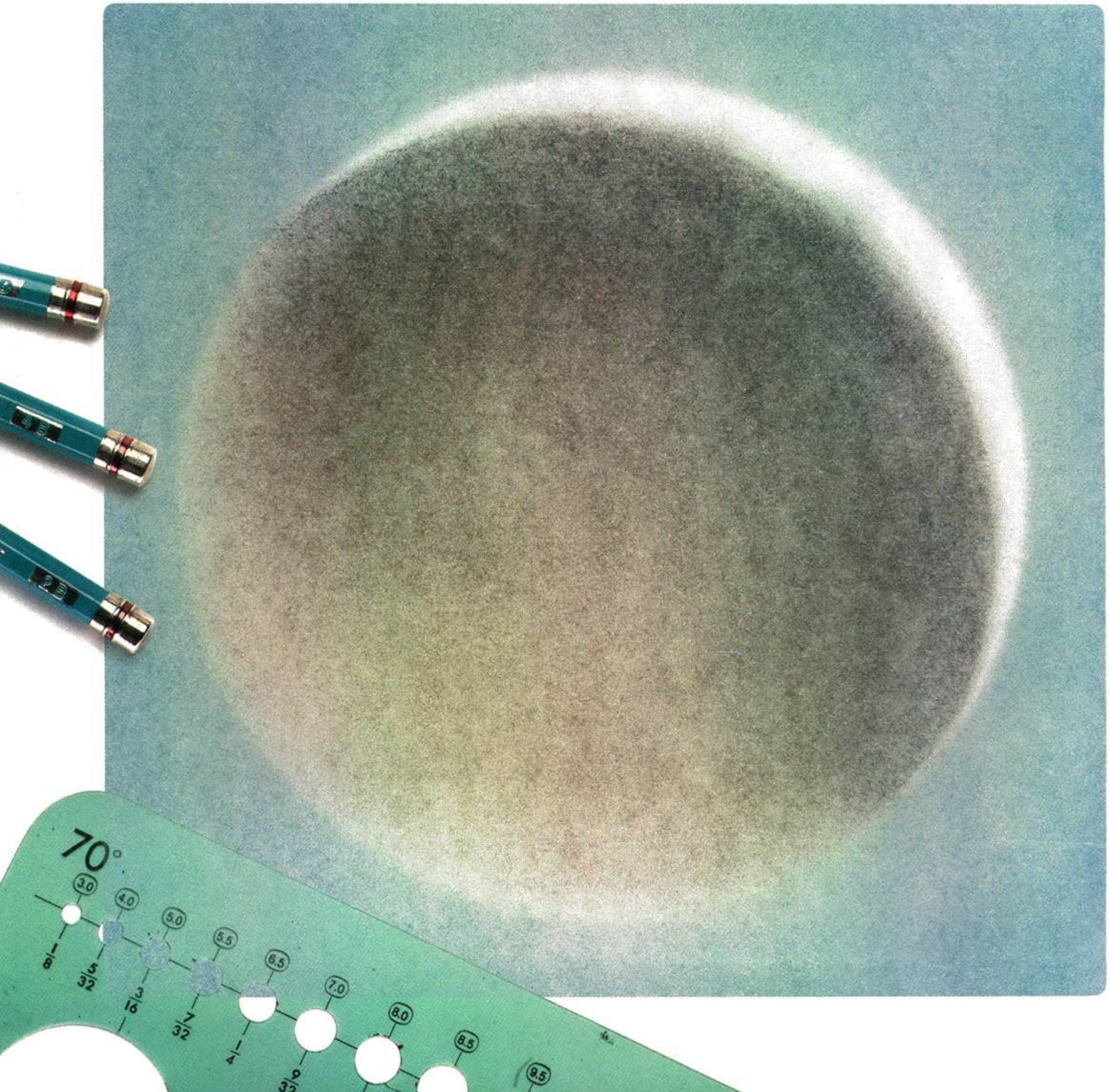
When it comes to an advanced instrument outfitted with all of the bells and whistles, the NexStar 8 GPS is a leader in the field thanks to its easy set-up, ergonomically friendly design, crisp optics, and intelligent options. Any amateur astronomer who enjoys an automated tour across the sky, astrophotography, or even a casual star-hop across the universe (and that's just about all of us) will find that the high-tech NexStar 8 GPS provides good old-fashioned fun.

Phil Harrington's equipment reviews appear often in Astronomy. *His book* Star Ware *is available through bookstores and his website –* www.philharrington.net.

SKETCHING THE SOLAR

Sketching planets isn't about art. It's about seeing more with your telescope — and recording your observations.

by Lee Macdonald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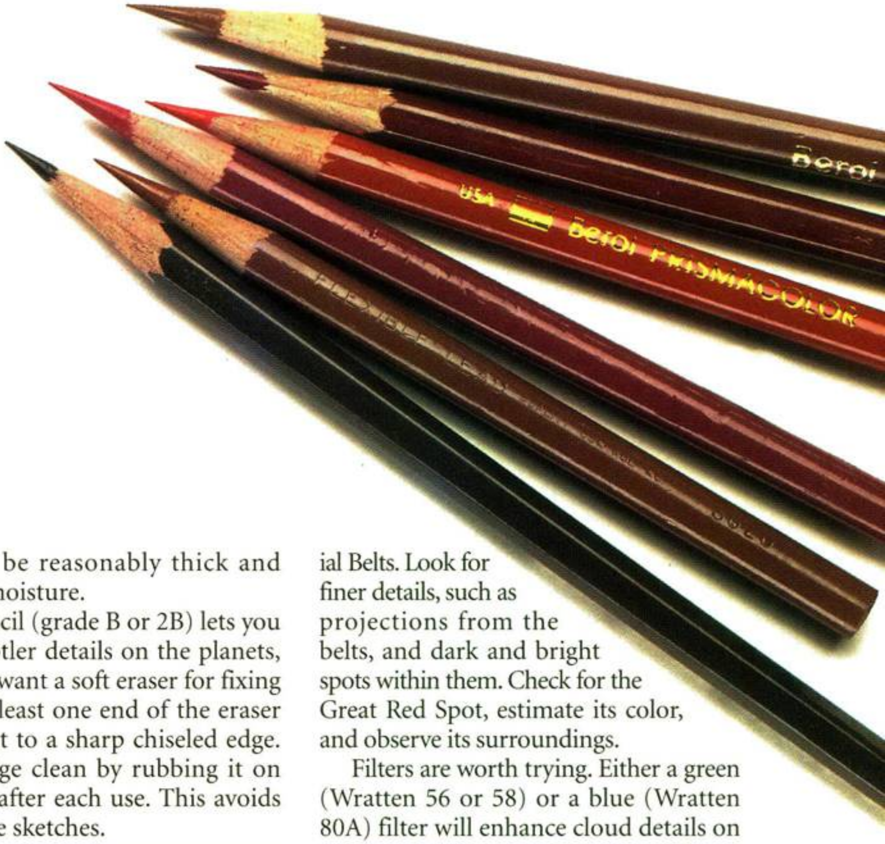


EVERY ARTIST KNOWS THAT WHEN YOU draw something, you observe it more closely. Drawing — even a rough sketch — focuses your attention on the subject. All skygazers can benefit from this technique, but planetary observers most of all.

The brightest and easiest planets to view are the same ones that undergo appearance changes. Backyard observers discovered the Great White Spot that erupted on Saturn in 1990. And amateurs continued monitoring the scars from the impacts of Comet Shoemaker-Levy 9 on Jupiter longer than most major observatories.

Sketching is an easy, inexpensive way to record such changes. Also, experienced observers see and record more detail than any photo, because atmospheric turbulence in Earth's atmosphere blurs details during the exposure. Most important, sketching encourages long looks instead of short glances.

The Telescope Studio

A complete sketching kit is quite basic — see "Sketching Gear," page 90. You need only a few of these items at the telescope, since you won't make finished drawings there.

I prefer to use a bound art notebook, since loose pages can blow around and get lost in the dark. I like using a hardcover book about five by eight inches, with unruled pages. The paper should have a slight texture, but not too rough. It should also be reasonably thick and resistant to moisture.

A soft pencil (grade B or 2B) lets you draw the subtler details on the planets, and you will want a soft eraser for fixing mistakes. At least one end of the eraser should be cut to a sharp chiseled edge. Keep this edge clean by rubbing it on blank paper after each use. This avoids smudging the sketches.

Finally, illuminate your notebook with a red LED observer's flashlight. (Avoid white light; it ruins night vision.) Mount the flashlight so it leaves your hands free while evenly illuminating the page.

How to Sketch a Planet

The four brightest planets — Venus, Mars, Jupiter, and Saturn — are the easiest to sketch. Although they differ in appearance — Venus with its phases, Saturn with its rings, and so on — you use the same basic skills with all of them. As an example, let's do Jupiter, the planet that shows the most detail in backyard telescopes.

I recommend observing and sketching while sitting down at the eyepiece. Being seated comfortably is important.

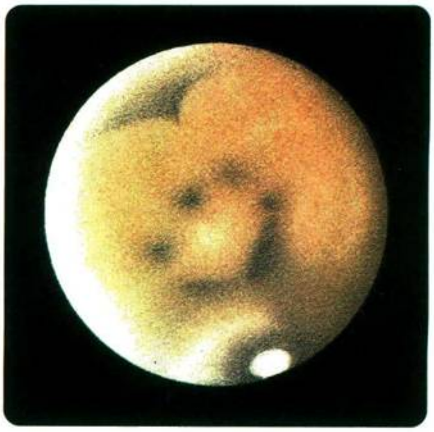
Examine the planet briefly to see the features' layout. Use several eyepiece magnifications, but keep them low enough to avoid unsteady seeing. Examine the dark belts and bright zones first, noting their relative thickness and positions on the globe. Can you detect any thin belts between the major ones? Sometimes an Equatorial Band is visible midway between the North and South Equatorial Belts. Look for finer details, such as projections from the belts, and dark and bright spots within them. Check for the Great Red Spot, estimate its color, and observe its surroundings.

Filters are worth trying. Either a green (Wratten 56 or 58) or a blue (Wratten 80A) filter will enhance cloud details on Jupiter, Saturn, and Mars. Red filters (Wratten 21, 23A, or 25) bring out martian surface markings.

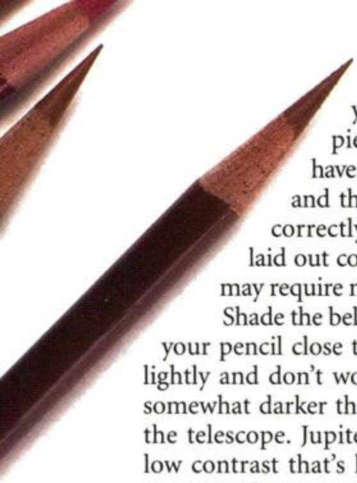
Having examined the planet, you're ready to begin drawing. Jupiter is noticeably oval, so use a special outline or blank form to sketch its features. Blank templates are available online at the Association of Lunar and Planetary Observers (ALPO) website (see "Resources", page 90). You can also trace a 70° ellipse template, or even trace a Jupiter outline from this article or Sky Show, page 60. A diameter of 2 inches or 50mm is ample.

Now, outline the cloud belts. Use the grade B pencil, pressing lightly. Draw the two equatorial belts first, then work toward the dusky polar regions. If the Red Spot is visible, draw its outline. When you have finished, compare your diagram with what

Richard Baum, of Chester, England, captured the ethereal beauty of Venus as it is typically seen at dusk or dawn. The planet's dark area was distinctly brighter than the sky and showed a coppery hue. Baum made the sketch on March 21, 1953, with a 3-inch refractor at 120x.



When it lies close to Earth, Mars is a popular subject, as it offers the greatest array of detail to those who sketch planets. Richard Baum drew the Red Planet from Amazonis to Elysium on June 18, 1984. Baum used a 4.5-inch refractor at 186x.



you see in the eyepiece. Make sure you have located the positions and thickness of the belts correctly. Getting the belts laid out correctly is tricky and may require more then one try.

Shade the belts evenly by keeping your pencil close to horizontal. Work lightly and don't worry if the belts are somewhat darker than you see them in the telescope. Jupiter's features have a low contrast that's hard to capture on paper. Try, however, to shade their relative intensities correctly. When the belts are shaded, fill in the finer details.

Next, look for plumes between the equatorial belts. Estimate their positions as fractions of their distances along the belt. You may see two projections join to make an arch; these are known as loop festoons. Carefully draw what you observe. Note that belts often have wavy edges punctuated with small, round bumps. Look for dark and white spots anywhere on the planet, especially near the edges of the equatorial belts. Finally, look for darker and lighter areas within the equatorial belts. Dark areas can be shaded accordingly, but light areas require careful erasing. White spots visible against a light background should be drawn with dotted lines.

Work swiftly with Jupiter. For accuracy, each drawing should be completed within about 15 minutes, as Jupiter's rotation causes features to shift significantly over longer periods.

Complete drawings aren't always very pretty. Don't worry, this isn't art class. As long as feature positions and relative brightnesses are accurate, it's fine. Don't waste time at the eyepiece smudging features for realism or adding color. Just write down where you see it.

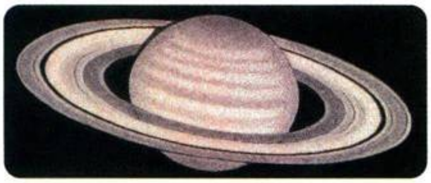
Before you leave the telescope, note several pieces of information. These include the date and the starting and finishing times of your observation, and the telescope specs, including magnifications and filters used. Also estimate the seeing with either of two scales. One runs from 0 (very bad) to 10 (perfect). The other, known as the Antoniadi scale, runs from I (perfect) to V (very poor). Finally, note as much information as possible about what you saw, particularly anything unusual. This is important for interpreting your drawings if you produce finished versions.

Sketching Mars, Venus, and Saturn

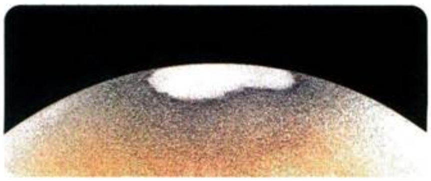
Venus and Mars are both spherical, so use a circle outline. Choose one large enough to draw details accurately — a 2-inch (50mm) diameter is common, but some prefer 1 to 1.5 inches (25 to 40mm).

Mars is fascinating to observe, but it comes to opposition only once every two years — and only for a few months during each apparition does it appear large enough to show much detail. Thus it's a good idea to begin observing Mars early in an apparition. This trains your eye to make the most of the important months. The more you observe Mars, the more detail you'll see.

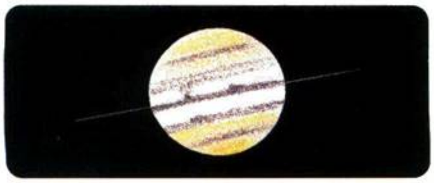
The first step is drawing Mars's phase. This is a small effect, but the planet will look gibbous a few months away from opposition. (See Sky Show, page 60.) Then outline whichever polar ice cap is visible. Next, outline the larger dark markings. Shade these as you see them in



French observer Jean Dragesco took advantage of spectacularly steady seeing to draw Saturn at 800x using a 4-inch refractor. The drawing, which shows finely delineated ring divisions, was made on December 22, 1976, from Pic du Midi, France.



A detailed drawing of the martian south polar cap reveals indentation in the ragged, icy edges. Richard Baum made the drawing on August 17, 1971, with a 4.5-inch refractor at 186x. Notice how he uses shading to give the planet a 3-dimensional feel.



Patrick Moore's drawing of Saturn with edge-on rings captures the subtle ocher color typically visible in backyard scopes. The drawing was made on February 24, 1980, with a 24-inch scope at 815x. During its orbit, Saturn presents its rings from a variety of angles.

Sketching Gear

- Artist's notebook with lightly textured blank pages, or sheets of heavy paper for making blanks on a laser printer
- Drawing pencils, grades 4B, 2B, B
- Pencil sharpener
- Plastic (white) erasers, retractable and block
- Cotton swabs
- Cotton balls
- Circle template with diameters up to 2 inches
- Ellipse templates, 5° to 70°
- 15° to 60° combo-assortment of ellipses all on one template
- Storage box

Resources

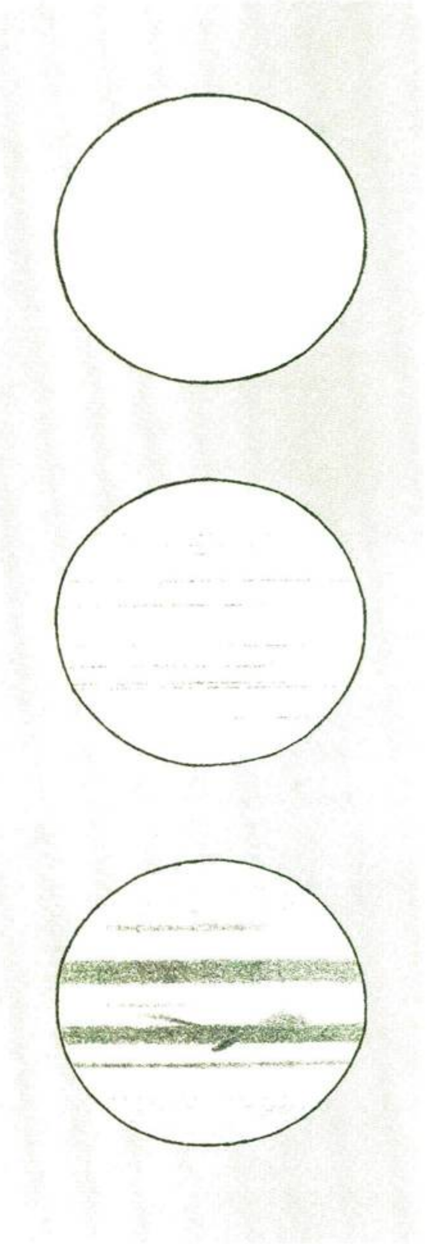
Association of Lunar & Planetary Observers
www.lpl.arizona.edu/alpo/

British Astronomical Association
www.britastro.org/index.html

Both associations have observing sections devoted to each of the planets. Check the specific planet web pages for observing forms and templates.

Art-instruction books on drawing contain a lot of advice on choosing pencil grades, using erasers and smudgers, and other techniques handy for planetary sketchers.

The author's three-frame sequence uses Jupiter to show the rough stages of a planetary drawing. (1) Trace an oval the same shape as the planet you wish to draw. (2) Sketch the outlines of the cloud belts. (3) Shade the cloud belts, and then add smaller features such as zones and spots.



the eyepiece. Finally, fill in fine details, such as darker regions. Regions lighter than the overall hue of the planet, such as the Hellas Basin or occasional clouds and hazes, should be delineated using erasures and dotted lines.

Venus greatly contrasts Mars. Its phase varies from crescent to full. Sketch the phase carefully. Its surface is covered in white clouds, showing only subtle atmospheric details. Drawing it is a challenge. The first "surface feature" you may notice is an uneven shading along the terminator, the line dividing night from day. Sketch this by pressing firmly with the pencil next to the terminator, then more softly farther out. The poles appear slightly brighter, making polar hoods that can be drawn with a solid line. The southern hood is often bordered by a slightly darker region. The rest of Venus shows only slight variations in hue. As with Mars and Jupiter, draw the outlines of features before shading them in.

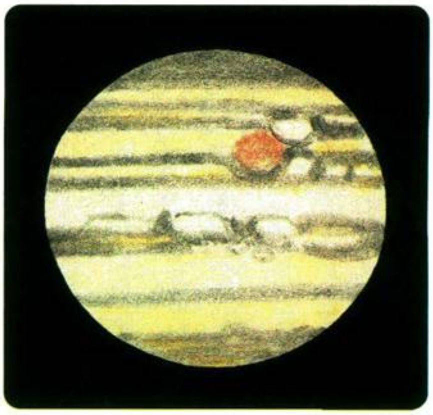
Saturn's rings and flattened globe require a special outline. Its silhouette also changes from year to year. ALPO has online blanks, or you can trace the outline in Sky Show on page 60. Saturn's features are less distinct than Jupiter's, and it has fewer spots and markings.

Start drawing Saturn by concentrating on the globe. Draw in the most prominent belts, working outward to the polar regions. Estimate the positions of the belts as fractions of the distance between the rings and the limb of the planet. Then draw the rings' Cassini Division and the shadows of the rings and globe. Drawing smooth curves is difficult at first but improves with practice. Try to make the widths as accurate as possible — it's easy to draw the Cassini Division too wide. Notice that the outer A ring is slightly darker than the middle B ring. Also look for the C, or crepe, ring, the faint innermost one. Shade it dark gray.

Making Finished Drawings

For display or for an observing archive, work up finished sketches. You need a soft, grade 4B pencil, cotton swabs, and cotton balls. Remember the positions and relative brightnesses of the features should be the same as those on the original sketch.

Use the Jupiter sketch made earlier. Draw an outline of Jupiter the same size as before, then blacken the surroundings with a black marker pen to create a planet-in-space effect. Lightly shade the entire outline, keeping your pencil as close to horizontal as possible to make the shading even. Blend the shading by rubbing the entire blank with a cotton ball. You may wish to create a 3-D effect by slightly shading the edge of the planet to record its limb-darkening.



British observer Patrick Moore's finely finished rendition of Jupiter shows the Red Spot in color, as well as a number of white clouds. Moore made the drawing on February 13, 1967, using a 10-inch scope at 360x.

Now you are ready to copy your sketch onto the new outline. Take time to copy it carefully and accurately, measuring the distances between the belts if necessary. When you have finished, carefully smudge the belts by rubbing them with a cotton ball until they look as smooth as they did in the eyepiece. Do the same with smaller features — spots, projections, and so on — using a cotton swab. Draw white spots and bright rifts in the belts by carefully rubbing out the desired area using a clean, chiseled-edged eraser, or a putty eraser for very small features.

If you wish, you can make realistic color drawings showing the subtle browns and creams of planetary features as they appear.

Send finished copies (or scans) of your best sketches to *Astronomy*, to the Association of Lunar and Planetary Observers or to the British Astronomical Association (BAA). Both ALPO and BAA have collections of observations going back many decades. Drawings can be scientifically important. One of your drawings may show an unusual development on Mars or Jupiter. Until there's a space telescope like Hubble monitoring each planet all the time, backyard planetary observers will remain important. ■

Lee Macdonald has long been a keen visual observer and currently uses a 222mm (8-inch) Dobsonian reflector

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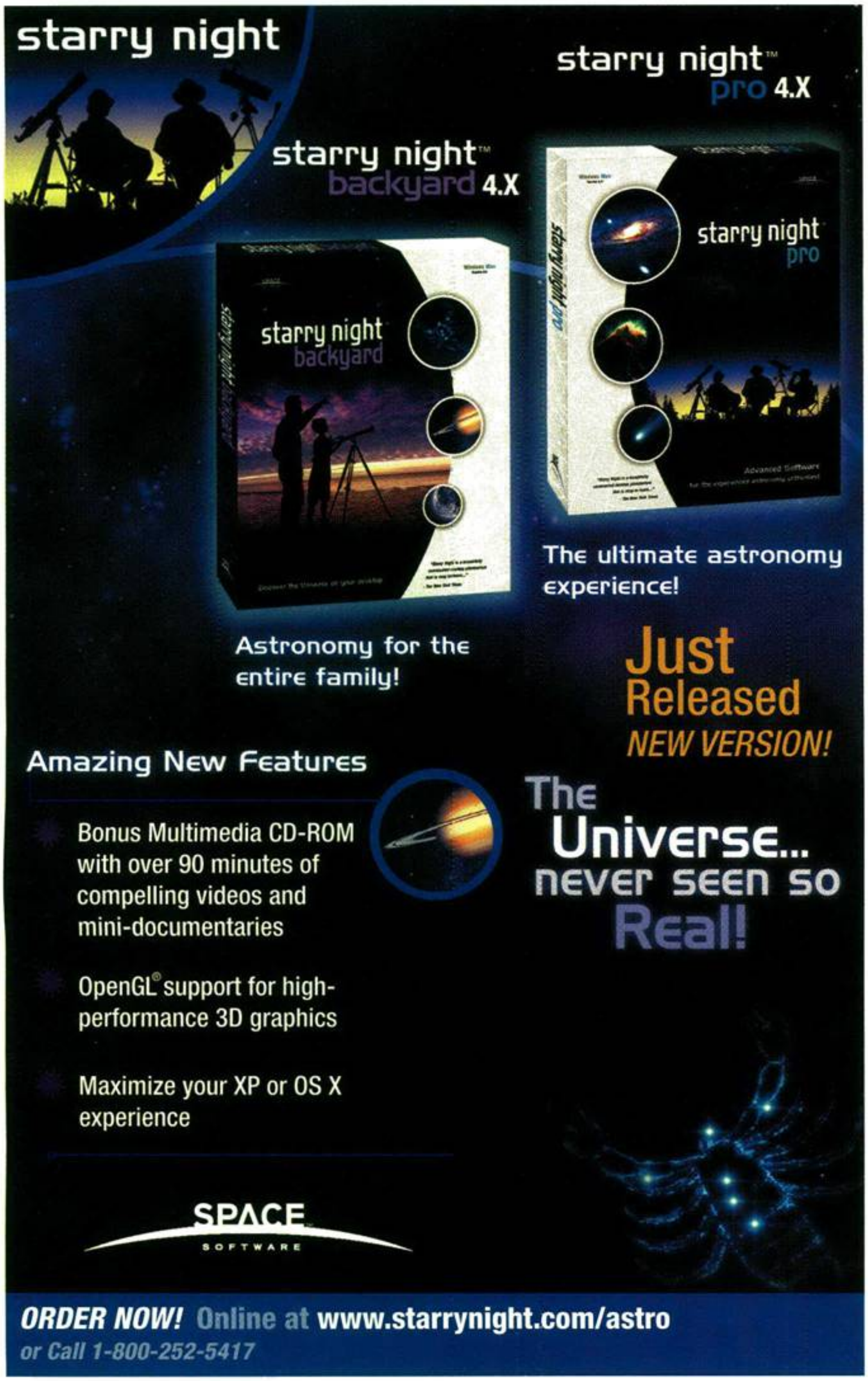

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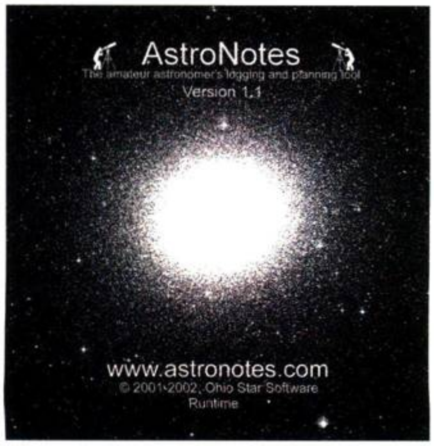
The fact that *AstroNotes* is built with Microsoft Access, a popular database application, means that all of its reports can be exported to other common programs such as Excel and Word. Be sure to state in your order whether you already have Access installed on your computer — this will affect the software version you receive.

For those unfamiliar with database applications and their vast array of features, be prepared for a fairly steep learning curve. Also, the graphics design is a little disappointing. But Ohio Star Software's first foray into the amateur astronomer market is a low-cost, no frills program that gets the job done by creating a highly usable, powerful archive for the long-term active observer.

$19. Ohio Star Software, 14832 Siefkes Court, Wichita, KS 67230; website, www.astronotes.com; Minimum requirements: Windows 98; 200 MB disk space.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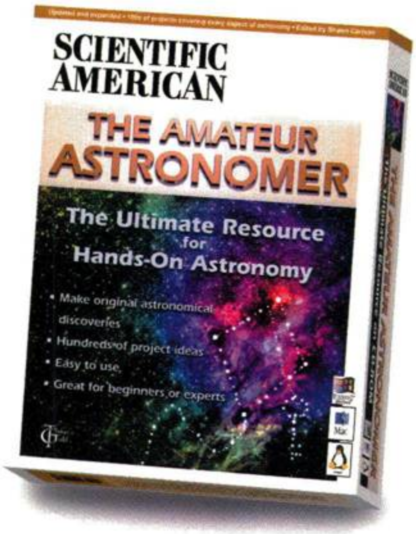
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Scientific American: The Amateur Astronomer

▶ Created for those who like to tinker and build, the aptly named Tinker's Guild presents *Scientific American: The Amateur Astronomer*, a library CD-ROM. The heart of this product lies in its searchable archive of the magazine's "how-to" science column published throughout most of the 20th century. A web browser displays astronomical topics ranging from building observatories to photographing comets. For those keen on trying a project, a fairly subjective rating system shows the level of difficulty, cost, and any potential hazards. A search function allows users to browse the archive by decade or by subject.

The CD-ROM touches on a number of groundbreaking inventions and astronomical techniques. Many of these changed backyard astronomy, such as the home-built star tracker that follows the movement of stars, and cold cameras that brought astrophotography to new levels. With the advancement of computers and CCD cameras, most articles in this archive have more historical than practical value, but this product could become a solid reference for hands-on hobbyists and educators.

$18.99. Tinker's Guild, 410 Tiogue Avenue, Coventry, RI 02816; (401) 823-7367; website, www.tinkersguild.com; Minimum requirements: 32 MB RAM, Netscape 4.0, or Internet Explorer 4.0, Win/Mac/Linux/UNIX.

Deep Space Explorer

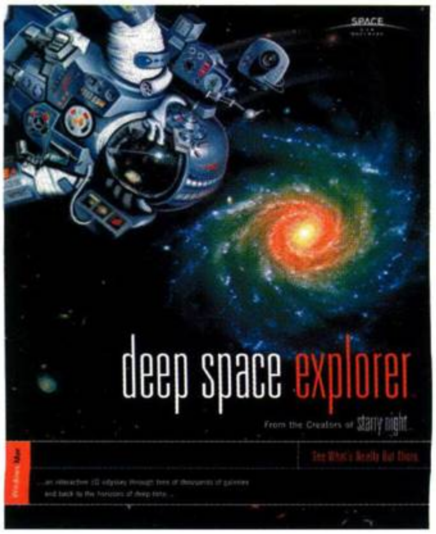
▶ Galaxies, galaxies, and more galaxies is what you'll get with *Deep Space Explorer*, from the makers of the home planetarium program *Starry Night*. This interactive multimedia CD-ROM lets home users fly at warp speeds through 28,000 nearby galaxies. With a click of the mouse, armchair astronomers can pilot their personal intergalactic spaceships anywhere within a 350-million-light-year radius in glorious 3-D.

Unfortunately, galaxies are highly pixilated at close range, and overly sensitive spaceship controls make it frustratingly easy to overshoot galactic destinations. While more than an hour of entertaining movie clips cover topics from satellites to black holes, famous deep-space destinations such as the Orion and Eagle nebulae have been curiously omitted from the database.

Deep Space Explorer is oriented to more experienced space buffs, as well as high-school and college classrooms, and would work well as an add-on to a planetarium program. Its stunning visuals set a new standard for hyper-realistic home astronomy programs.

$49.95. SPACE.com, 284 Richmond Street East, Toronto, Ontario, CANADA, M5A 1P4; (800) 252-5417; website, www.starrynight.com; Minimum requirements: Windows 95 or Mac PowerPC; 32 MB RAM, 150 MB disk space.

— All reviews by Andrew S. Fazekas, a science communicator based in Montreal who conducts multimedia astronomy presentations for general audiences.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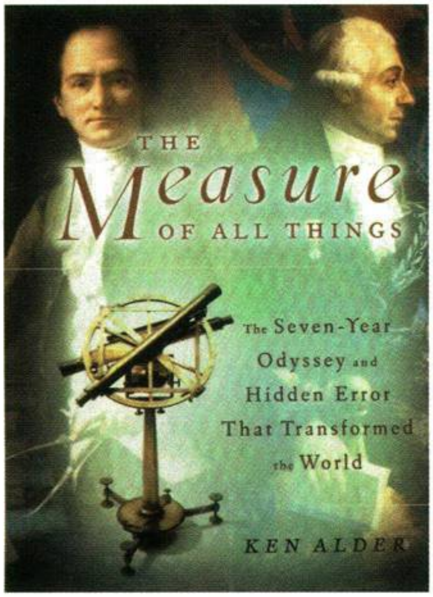

THE
Measure
OF ALL THINGS
The Seven-Year
Odyssey and
Hidden Error
That Transformed
the World
KEN ALDER

The Measure of All Things

Ken Alder, 432 pages, Free Press, New York, 2002; ISBN 0-743-21675-X; hardcover, $27.

▶ In the late 1700s, the measurement system in France was in disarray. A loaf of bread weighed something completely different from one town to another. Even the distance between the towns could not be measured uniformly because there was no single, well-defined unit. The French Revolution, however, provided the chance to start anew, and one of the first acts of the National Assembly was to develop a set of standard units. Rather than basing them — as their neighbors across the pond did — on an anthropomorphic quantity such as the length of a ruler's foot, they would be based on the Earth. The fundamental unit became the meter, defined to be exactly one 10-millionth the distance between the North Pole and the equator.

Appointed were two astronomers, Jean-Baptiste-Joseph Delambre and Pierre-François-André Méchain, to calculate the meter's precise length. The process was simple enough in theory — the Greek scholar Eratosthenes had used a similar method when he measured Earth's diameter some 2,000 years earlier. For that calculation, he sighted the Sun's shadow down a well in Syene, Egypt, and compared it to similar measurements some 800 kilometers north in Alexandria.

For their part, the modern pair traversed France and its environs — Méchain heading south to Barcelona, Delambre north. Along the way, they encountered superstitious peasants, clashing armies, epidemics of malaria, months of sleet and rain, and citizens who were perfectly happy with their old system of units. But they endured, hoping their measurement would unify the new republic and be the most accurate ever made.

They used meticulous observations of stellar elevations; precisely aligned surveying equipment; and hundreds of sightings, from church tower to mountaintop to belfry.

Unfortunately, their measurement was far from perfect due to a series of errors — some technical, some philosophical, some due to the study's flawed design. In fact, every meter stick manufactured today propagates the error, being short the intended pole-equator definition by 0.2 millimeter (today's meter measures the distance light travels in $^1/_{299,792,458}$ second). It is a small amount, perhaps, but undesirable considering the purpose of the device.

Both standard-bearers secretly knew of the mistake, and Méchain was so ashamed he disavowed his results and the entire seven-year project. He left his family, and died trying to untangle the mess he believed he'd made, hiding the evidence of any scientific malfeasance.

Regrettably for Méchain's legacy, historian Ken Alder has uncovered the story. His research is exhaustive on counts both scientific and biographical. He relies on many previously unpublished sources, including detailed letters between the two surveyors kept under seal since the early 1800s in the Observatoire de Paris.

Alder's writing sparkles with wit and life. The book melds historical documentary, riveting biography, scientific discourse (on error analysis and measurement), and personal essay (on the relative merits of global standards and local traditions). Alder's deft handling of the web of interactions between people, governments, technology, and science brings a relevance and humanity to the French Revolution — and to its connection to the seemingly distant subject of astronomy.

But like the meter itself, the book is not perfect. The illustrations (mainly historical photographs and maps) are wholly inadequate; a few modern diagrams and maps are sorely needed. Explanations of the methods are sometimes surprisingly incomplete. For instance, triangulation measurements were described as using "reflectors," but the author refers to "lighting" these without explaining what he means. And, not until well into the book — and in passing — does Alder mention that the surveyors did not measure the entire pole-equator distance, but only the length of France.

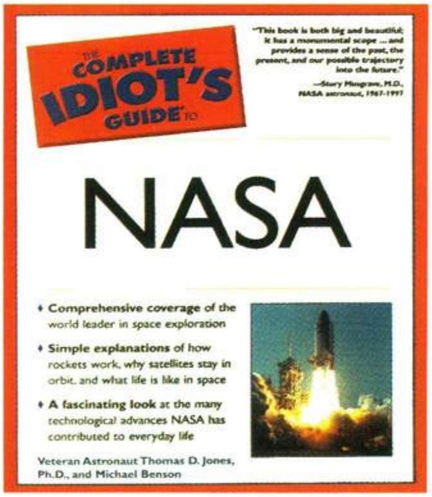
The number of backtracks, over-winterings, and run-ins with border personnel throughout the book is overwhelming. But, although these drawbacks occasionally make traversing the meter's convoluted route too true to life, it is difficult to criticize such a largely wonderful work. I believe it will take its rightful place as a classic in the history of science. Vive le mètre! — *Henry Throop is a scientist at the Southwest Research Institute in Boulder, Colorado. He is involved with the Cassini mission to Saturn, and is pleased to use the metric system on a daily basis.*

The Complete Idiot's Guide to NASA

Thomas D. Jones and Michael Benson, 360 pages, Alpha Books, Indianapolis, Indiana, 2002; ISBN 0-028-64282-1; softcover, $18.95.

▶ Hardly a week seems to pass without a rocket launch or a high-flying satellite making some kind of cosmic discovery. More often than not the National Aeronautics and Space Administration (NASA) is behind these momentous achievements in space exploration.

The Complete Idiot's Guide to NASA brings to light the celebrated and sometimes secretive world of NASA. Written in a straightforward style, this guide provides a fascinating glimpse into the world's leading space agency.


THE COMPLETE IDIOT'S GUIDE TO
"This book is both big and beautiful; it has a monumental scope ... and provides a sense of the past, the present, and our possible trajectory into the future."
—Story Musgrave, M.D., NASA astronaut, 1967-1997
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• Simple explanations of how rockets work, why satellites stay in orbit, and what life is like in space
• A fascinating look at the many technological advances NASA has contributed to everyday life
Veteran Astronaut Thomas D. Jones, Ph.D., and Michael Benson

Starting with simple discussions on topics such as what makes rockets go and how NASA does business, this book doesn't assume much previous knowledge. The reader is taken back to the dawn of the space age, which was filled with tragedies, triumphs, and legendary characters. Later chapters explain in user-friendly terms the complex engineering concepts behind the technology used to explore outer space.

Part of the guide's strength lies in coauthor Thomas D. Jones's intimate familiarity with the space agency. A veteran astronaut with four shuttle missions to his credit, Jones is an accomplished author and planetary scientist who has helped plan future robotic missions to Mars and the outer solar system. Readers are treated to what it's like to be a real life "Buck Rogers" in the introductory chapters, where Jones relays his adventures becoming a shuttle astronaut. Michael Benson, the other coauthor, is a skilled writer of more than a dozen books, including other volumes in the *Idiot's Guide* series.

Each chapter begins with a list of key concepts to be covered and ends with a "Least You Need To Know" section briefly summarizing pivotal historical events. Sidebars explain space jargon and highlight space trivia. Also amusing are Jones's personal observations, many of which concern the difficulties of human spaceflight.

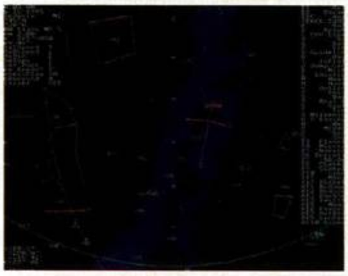
Unfortunately, many of the biographies of astronauts are unnecessarily long, and the hallmark humor of other *Idiot's Guides* is sadly missed.

Only a few dozen pages are devoted to the robotic planetary exploration missions carried out by NASA's Jet Propulsion Laboratory. Also, the book is somewhat unbalanced: Criticism of the politics of the space shuttle and space station are kept to a minimum, with much lauding of the benefits of human spaceflight to everyday life.

That said, this is a wonderful reference guide to America's space agency. Although much of the book's information is also available on the Internet, space lovers will be hard-pressed to find such a thorough, accessible history of spaceflight in one publication. — *Andrew S. Fazekas is an astronomy columnist and science communicator based in Montreal.*

The Webweaver Picks

by Richard J. Bartlett



▶ Unlike those people in the *Back to the Future* movies, no one in reality has a time-traveling DeLorean. If you want to see how the sky will appear in the future or recall those starry nights of the past, you're going to need some planetarium software, some of which is available online.

While these programs are not detailed enough to accurately plot the course of an asteroid or comet, they are useful for helping you find your way around star patterns.

One of the simplest is also one of the oldest and most popular. *SkyGlobe* can be downloaded as a 1.3MB executable file for all Windows platforms from several sites, including http://astro4.ast.vill.edu/skyglobe.htm. If you're running Windows XP and have trouble with the latest version, 4.0, try version 3.6 from www.simtel.net/pub/pd/40379.html.

SkyGlobe will plot the positions of the stars and planets for almost any given year, date, and location on Earth. It will even take into account the effects of precession, making it possible to go back to ancient Egypt and see for yourself which star the Pyramids were aligned with.

Another advantage is its speed — set the "fast forward" option running and watch the stars rise and set as the planets dance around the Sun. The downside, at least to version 3.6 used for this review, is that the Moon is shown only as new, full, or one of the quarter phases, and the planets are depicted merely as colored circles. *SkyGlobe* is shareware. Registration costs $20, which can be sent to the address shown when you exit the program.

One program that unfortunately doesn't show the Moon or planets at all is *MIRAPLA*, a DOS-based freeware program by Fausto Ballardini and Fabio Cavicchio. This is available for Windows from www.sira.it/msb/eng.htm as a 123K zipped file. It's pretty simplistic and there are no "read me" or "help" files, so press F1 or the ESC key for the basic commands. It has fewer features than *SkyGlobe* but for a DOS program, the night-sky views are quite realistic.

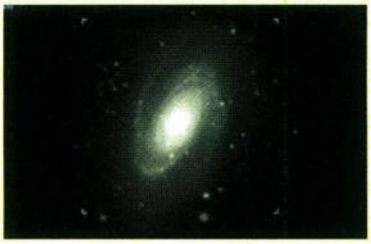
If you're looking for an even better simulation of the skies, try *CoolSky* by Piotr Czerski. It's shareware that costs $25 to register, but you can download a 1.8MB zipped trial version for Windows from www.astronomica.com. Registering allows you to print sky views and includes photographic images of deep-sky objects. *CoolSky* simulates the night, day, and twilight hours quite nicely, rendering the Milky Way as more than just a colored blob. Wispy clouds scoot past over time, and the stars, aside from exaggerated colors, look realistic. The Moon is reasonably depicted, but disappointingly, the evaluation copy showed the planets simply as colored dots.

Look out, too, for *WinStars* by Franck Richard, a freeware program for Windows available from http://winstars.free.fr/english. The main program downloads as a 3MB executable file, with six optional downloads for additional stars, Messier objects, the Milky Way, and more accurate planetary satellite positions. For a free program, it's quite impressive and comes with a realistic landscape, an orrery, an ephemeris generator that calculates notable events, a definable eyepiece circle, LX200 telescope control, and a night-vision mode.

On the downside, zooming in and out is cumbersome and displaying the landscape slows the program down considerably. When using the "Find" option, the object you're looking for becomes partly obscured by the crosshairs.

Of all the freeware programs available online, by far the most photo-realistic is *Stellarium* by Fabien Chereau. Some of the views generated are quite stunning — you'll find yourself wishing for a large projection screen to fully immerse yourself in the experience. The Messier objects are all included (some in color, but most in black and white), the Milky Way looks great, and the stars even twinkle (check out the ample selection of double stars).

Be warned — the program isn't perfect. You can't set the time and date yourself, although you can move quickly forward and backward through time. And although the Moon phase is correct, the graphic isn't of the Moon itself — surprising given the attention to detail found elsewhere. Pluto's position is inaccurate, the planetary satellites aren't displayed, and the images for the superior planets are simply standard photos. You can only set your location to the nearest degree and you have to adjust for Daylight Savings yourself. Lastly, twilight comes and goes pretty quickly, and at those times the Milky Way has a strange habit of turning yellow!



Stellarium can be downloaded as a 2.2MB zipped file from http://stellarium.free.fr and runs on Windows 95/98/2000/XP and Linux operating systems.

With any one of these programs you're sure to get a good view of what's coming up in the skies above — without the need for a costly DeLorean. Mad professors are, of course, optional. — *Visit Richard's StarLore website at http://www.starlore.net.*

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B. MIZON, British Astronomical Association, London, UK

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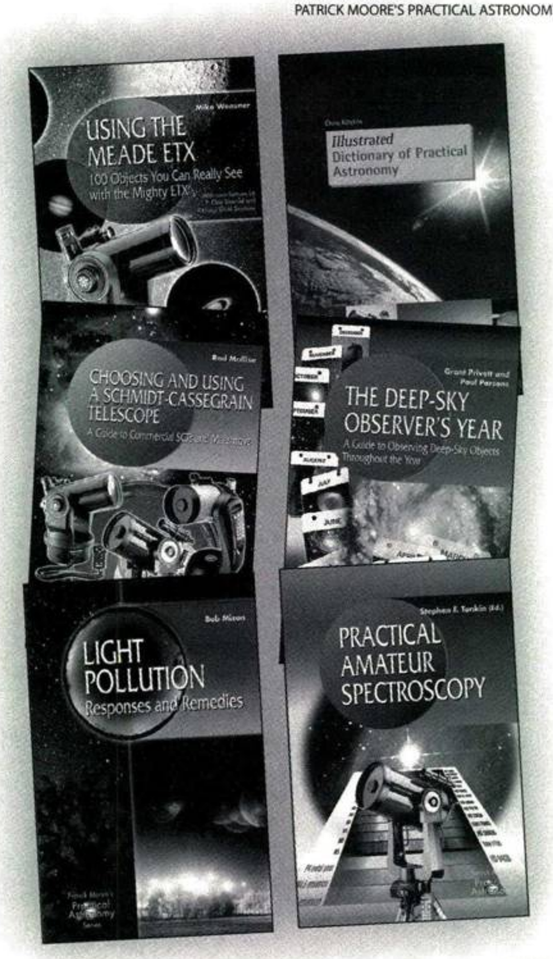
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2002/APPROX. 128 PP./SOFTCOVER/$19.95 (T)
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G. PRIVETT, Crookham, UK; and
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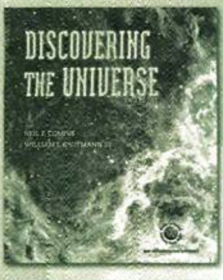

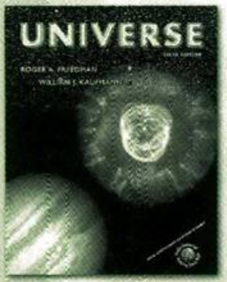

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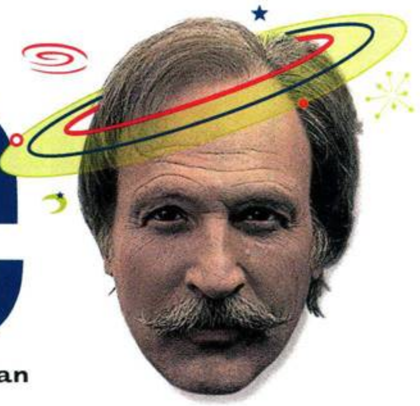

by Bob Berman

No Astronomers At All?

A certain professional West Coast astronomer is known for putting down backyard amateurs, calling them "no astronomers at all." Given the chance, I would tell him that it is often the backyard astronomer, rather than the professional, who deeply grasps the beauty and organization of the universe. Motivated solely by love of the starry cosmos, they're the ones who know what's where.

The telescope owner is like the art museum visitor who relishes a beautiful painting, while researchers are the ones who analyze the paint's composition. I believe the universe was born for the amateur astronomer's profound appreciative gaze, which serves as important a function as spectral analysis. In truth, both amateurs and professionals comprise an ideal human response to the nocturnal carnival of nebulae and galaxies.

The contributions of backyard astronomers are not usually recognized. But they should be. Beyond their important scientific accomplishments in areas such as variable stars or comet discoveries, many quiet unsung amateurs selflessly promote astronomy by generously sharing their time. They set up telescopes in parks or city streets, go to schools, give up precious leisure hours to introduce others to astronomy's allure. They help keep public interest high, which in turn aids professionals when it comes time for funding.

Let's focus on one person, Howard Yamasaki, as a fitting representative of the many amateurs who have amazed and impressed me over the years, and the thousands I've not yet had the pleasure of meeting.

Howard participated in *Astronomy*'s 2001 aurora tour, for which I was the lecturer. There were 50 wonderful people in the group who had come to experience central Alaska's gorgeous all-sky aurorae; Howard was clearly the most knowledgeable about astronomy.

Fast forward to Hawaii a few months ago. Yamasaki, a third generation Hawaiian of Japanese descent, had invited my wife and me to visit and go to the summit of Mauna Kea where I would be conducting interviews for an upcoming article. We were soon pleasantly enmeshed in his busy life as owner of two coffee and macadamia nut plantations.

As he and his gracious wife, Crystal, took us around the Big Island, and eventually up the fabled mountain in his four-wheel-drive vehicle, I gradually learned more about this remarkable, modest man and became captivated by his good humor. He laughed after every third sentence or so and seemed to find life perpetually amusing.

I'd already concluded that he had a strong character just from the way he handled the rats. Most Hawaiian agricultural enterprises must deal with rats, hordes of them. Strict government rules limit how they can be poisoned or killed, so many remain. Living in trees and (it seems) everywhere, they ravage a discouraging percentage of the ripening crop.

Rats don't merely bedevil Howard's plantation; they even manage to get into his home. He and Crystal often hear them in the attic, just above their heads at night, playing a bizarre game of rolling macadamia nuts down the attic floor like a bowling lane and then scampering after them. Rolling nut, scurrying feet, rolling nut, scurrying feet, over and over, all night long. The stuff of strange dreams. Even their cat won't go up there.

Howard's tough in other ways, too. Back in the '70s, he hiked and camped near the 14,000-foot Mauna Kea summit when 80-mile-per-hour winds blew away his tent in the middle of the night. Wham, gone. With freezing cold, howling gales, dizzyingly thin air, and no way down, he had to simply huddle there — and then deliberately spent three more nights as well. Nowadays when there's snow he'll ski or boogie board from the top, throwing himself off the edge between the Keck telescopes and the 80-inch University of Hawaii dome. This guy is no wimp.

By the late '70s, he and about five members of his astronomy club would often spend all-night sessions on the mountain. There, in the exquisite seeing for which Mauna Kea is renowned, the group observed odd, seemingly impossible radial "spokes" on Saturn's rings, finding them more than a year before the Voyager spacecraft made the official discovery. Back then only one small telescope adorned Mauna Kea, the University of Hawaii's 24-incher. Howard and his group were given the key to use it whenever it wasn't otherwise engaged. One night they confirmed their observation of Saturn's spokes with the professional telescope.

They'd often spend the night with their scopes at the 9,300-foot pull-off (this was before there was a visitor center). Using a detailed star atlas, Howard would study small sections of sky. Eventually he came to really know the heavens — and the mountain. He repeatedly lobbied and finally succeeded in getting permission to install permanent concrete piers that could be used by any visiting amateur with an 8-inch Cassegrain. (Today, visitors find wonderful telescopes waiting for them when they arrive; see *Astronomy* next month for details.)

Howard stands out in another way as well. As a teenager I'd memorized even all the third magnitude stars and their spectral classes, magnitudes, and distances just for fun, but who would want to do this now? The increased availability of "Go-to" equipment allows amateur scopes to slew anywhere at the push of a few buttons. Professional astronomers are renowned for not knowing the night sky, and no shame in that — it's not a necessity. But Howard (and maybe you, too?) is part of a vanishing breed who can find faint galaxies just by staring at the correct piece of celestial real estate. He'll use nothing but the finder on his 12-inch Dob or 10-inch equatorial.

Being possibly the first to discover Saturn's bizarre radial spokes and a successful early crusader for the amateur activity that is now available on Mauna Kea is still only part of the reason to spotlight Howard Yamasaki. What's most impressive is his generosity. He allows himself to be listed in guides as someone whom Hawaiians and visitors can turn to with their astronomical problems or needs. Schools and the Park Service periodically ask him to speak, and he frequently does.

Despite substantial demands from his own business (what the heck, let's plug his farm's wonderful gourmet Kona coffee: Pookela.com), he'll drop everything whenever possible for the astro-minded visitors, or help them get up to the fabled mountain, or drive a couple of hours to align the mirror of a lucky but clueless 18-inch owner.

Allow his home number to appear in this magazine? "Sure," he laughs, knowing full well the kind of unsolicited labor it may spawn. It's 808-328-9201, and remember Hawaiian time is six hours earlier than Eastern time. Don't wake him and Crystal in the wee hours.

They need their rat-sleep. ■

Bob Berman is a frequent contributor to Astronomy. *He is the author of several books, including the fascinating, humor-filled* Secrets of the Night Sky *(Harper-Perennial, 1996).*

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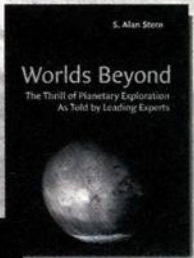
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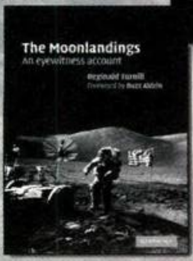

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Beginner's sky

Cosmic adventures for the neophyte astronomer. By Glenn Chaple

"Mirror, Mirror on the wall.
What is the grandest constellation of all?"

"Of the 88 star groups, one reigns supreme,
On a wintry night, its stars brightly gleam.
Four in a rectangle 'round a row of three more,
'Tis mighty Orion, the Hunter, of myth and lore."

All right, so now you know why I don't write poetry for a living. But were you to ask a magic mirror — or better yet, a group of amateur astronomers — to select the sky's most magnificent constellation, the odds-on favorite would be Orion.

Some constellations are larger, a few contain more naked-eye stars. Still others offer a richer selection of telescopic sights. But none can match the visual splendor of Orion — the sheer brilliance and eye-catching arrangement of its main stars (an upright rectangle with a belt of three stars running diagonally through its middle). Add the fact that Orion is the centerpiece of a spectacular gathering of bright stars and constellations and you understand why so many skygazers are willing to brave the cold winter's night just to glimpse it.

Centrally Located

Orion straddles the celestial equator, an imaginary band in the sky that lies directly above Earth's equator. In fact, Alnilam, the middle star in the belt, lies almost exactly on the celestial equator. If you were to stand on the North Pole and face southward, you would see the top half of Orion, with the belt skimming the horizon. South Pole observers would see just the opposite — Orion standing on his head, visible from waist down. What if you were on the equator? That's right — the great Hunter would pass directly above.

I was still in grade school when I "discovered" Orion shining regally above a snow-covered field near my home. All its stars were bright, especially two corners of the rectangle. I later learned that the top-left corner was Betelgeuse, a red supergiant whose magnitude ranges between 0 and 1.3, and the lower-right corner was the 0.2-magnitude supergiant Rigel, which, at 770 light-years from Earth, actually lies about twice as far as Betelgeuse. We'll talk more about stellar magnitudes next month.

Sighting the Hunter

As a middle-school science teacher, I always conduct my astronomy unit during the winter months, when Orion is visible. One of the easiest constellations to recognize, Orion serves as a guidepost for locating others nearby, and my students have no trouble picking it out.

Now it's your turn. Go outside an hour or so after sunset. Bring along a copy of this magazine (you'll need the pullout map in the center spread), plus a flashlight for illumination. To preserve your night vision, cover the end of the flashlight with a sheet of red cellophane, or mask the bulb with a coat of red nail polish. For observers in mid-northern latitudes, you'll find Orion by facing south and looking about halfway up from the horizon.

Stop in the name of ... Orion?

If you've had problems using a star chart to locate constellations, it may be because translating the size of the map's rendering to what's actually in the sky can be tricky. To approximate Orion's size, hold your hand out like a traffic cop giving the signal to stop: arm extended, fingers up. Fold your thumb so it rests in your palm. Your hand from wrist to fingertips now matches the area of the sky Orion occupies.

There's no need to rush your constellation search. If it's cold outside, quit early and resume your explorations the next clear night.

Orion forms part of a stellar celestial neighborhood — an area that contains one-third of the 25 brightest stars in the sky. We'll return next month to take a closer look at Orion and company.

Unidentified Shining Object

Being the "resident astronomer" in my community, I occasionally receive a phone call from someone asking me to identify an unknown object. Often this sighting involves a brilliant star visible above the horizon just before or after sunset. The star, the caller usually informs me, is much brighter than any other in the sky. That tells me the mystery object is the planet Venus.

For most of the first half of this year, Venus will dominate the morning sky, capturing the attention of anyone who happens to face eastward an hour or two before sunrise. What a dazzling sight it is — a brilliant white spark of light 16 times brighter than the brightest nighttime star. In fact, only the Sun and Moon outshine Earth's sister planet.

Venus is an arresting sight by itself, but the view is even more dramatic when a crescent Moon passes nearby, as it will on the morning of January 28.

If you're not a morning person, don't worry. When Venus moves into the evening sky later this year, you'll have several opportunities to view this beautiful alignment. How do I know? My magic mirror told me.

Glenn Chaple is a middle-school science teacher in Townsend, Massachusetts. Contact him at gchaple@astronomy.com.

Target Orion

Bill and Sally Fletcher

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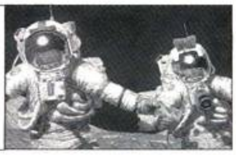

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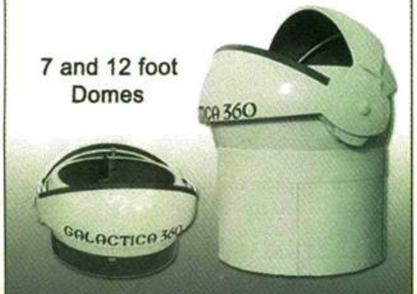

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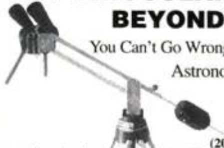

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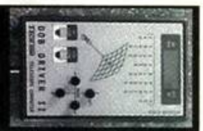

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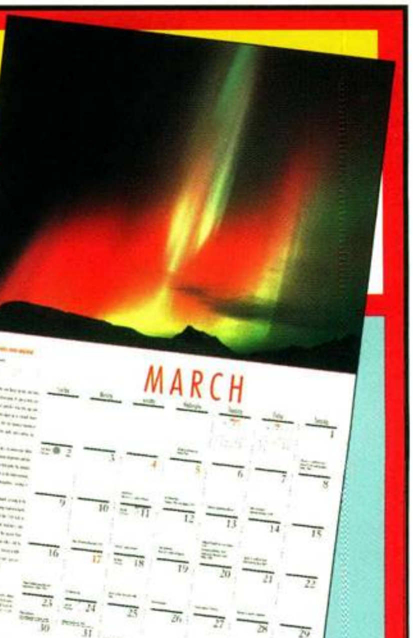

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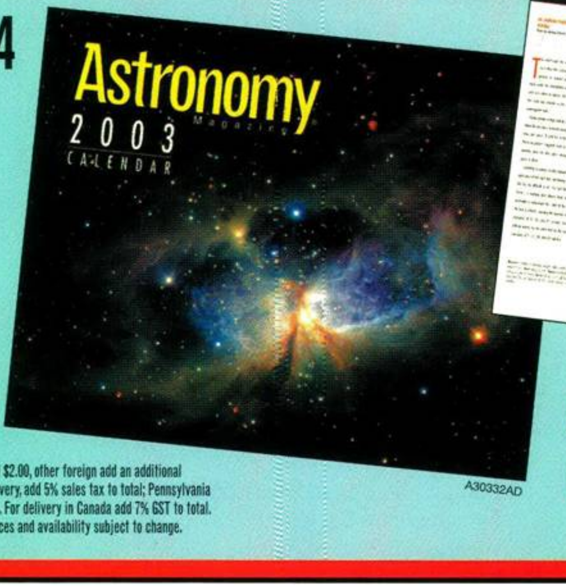

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For more information, contact Lucille or Fred Heinrich at 386–362–5995; 6165 Wiggins Road, Live Oak, FL 32060; fax, 386–362–5995; e-mail, heinrich1@alltel.net; or visit the SCAS website, www.scas.org/wsp.html, or the Florida Keys Tourism website, http://fla-keys.com/index.htm.

DECEMBER 6

Comets

Priory Street Centre, York, England. Jonathan Shanklin of the British Antarctic Survey will lead a discussion on comets. For more information, e-mail yas@talk21.com; website, www.yorkastro.freeserve.co.uk/.

DECEMBER 7–8

Star-B-Q

Leon Mow Dark Sky Site, Heathcote, Victoria, Australia. The 12th annual Star-B-Q is hosted by the Astronomical Society of Victoria. For more information, visit the website, www.asv.org.au/.

DECEMBER 14

Denver Astronomical Society Open House

Chamberlin Observatory, University of Denver. The Denver Astronomical Society's monthly open houses are an opportunity for the general public to learn more about astronomy. Members will bring their telescopes to share the splendors of the night sky with anyone interested. The theme for this open house is "How to Buy a Telescope." For more information, visit the society's website, www.denverastro.org/.

Astronomy: Robert Burnham

Sunshine, sand, and scopes await visitors at the Winter Star Party.

DECEMBER 21

The Day of the Sun's Return, Winter Solstice

Montgomery College Planetarium, Takoma Park, Maryland. For more information, visit the website, www.mc.cc.md.us/Departments/planet/.

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DECEMBER 28

Central Texas Star Party

Turner Research Station, Turnersville, Texas. In case of poor conditions, the alternate date is January 4. For more information, visit the website, www.centexastronomy.org/.

JANUARY 5–9

Annual Meeting of the American Astronomical Society

Washington State Convention and Trade Center, Seattle, Washington. Featuring lectures, discussions, and special events. The early registration deadline is November 27. For more information, visit the AAS website, www.aas.org/.

JANUARY 11–15

126th American Association of Physics Teachers National Meeting

Renaissance Hotel, Austin, Texas. The theme for this AAPT gathering is "Physics in Space." The AAPT will meet concurrently with the National Society of Hispanic Physicists. For more information, visit the website, www.aapt.org/.

JANUARY 16

How Stars Are Made

Chabot Space and Science Center, Oakland, California. Part of the Distinguished Lecture Series, this talk will be led by Steven Stahler, of the University of California at Berkeley. For more information, visit the Chabot website, www.chabotspace.org/.

JANUARY 25–JUNE 15

Little Bear's Wonderful Journey

Montreal Planetarium, Montreal. This program is oriented for young children and their parents. For more information, visit the planetarium's website, www.planetarium.montreal.qc.ca/.

JANUARY 29–FEBRUARY 2

Orange Blossom Special Star Party

Hickory Hill Observing Complex, near Brooksville, Florida. This event is sponsored by the St. Petersburg Astronomy Club. For more information, contact Dennis or Ellen Farr, 19309 Eastbrook Dr., Odessa, FL 33556; 813–792–0721; e-mail, dnefarr@aol.com; website at http://home1.gte.net/hoffmanc/.

FEBRUARY 1

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Adler Planetarium, Chicago. You can learn more about Benjamin Banneker, 18th-century scientist and astronomer, when the Adler presents the kickoff to African-American Heritage Month activities. From 11 A.M. to 3 P.M., you can make your own Banneker sky observer's almanac to use at home to view the Sun and Moon. SPIRITS drum and masquerade society performs a thrilling African musical performance at 1:15 P.M. Benjamin Banneker (storyteller/actor Oba William King) will also be there at 2:15 P.M. to tell stories about his life and experiences in the late 18th century. For more information, visit the Adler website, www.adlerplanetarium.org.

FEBRUARY 7–9

Impact Cratering: Bridging the Gap Between Modeling and Observations

Lunar and Planetary Institute, Houston. The purpose of this workshop is to discuss how physical observations of craters can be combined with the results from simulated impact models for a better understanding of the impact cratering process. For more information, visit the LPI website, www.lpi.usra.edu/meetings/impact2003/.

FEBRUARY 27–MARCH 2

Mid-Florida Stargaze

Fisheating Creek Campground, Glades County, Florida. The Astronomical Society of Palm Beach will host this event. For more information, contact the ASPB at P.O. Box 19652, West Palm Beach, FL 33416; website, www.palmbeachastro.org.

CONTACT

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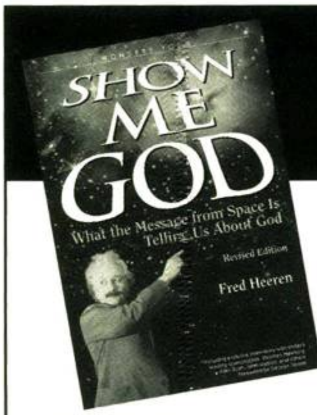

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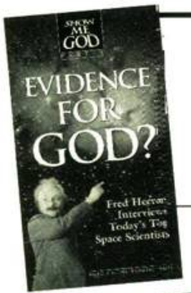

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17. I certify that the statements made by me above are correct and complete. Gerald Boettcher, President. Date: September 25, 2002

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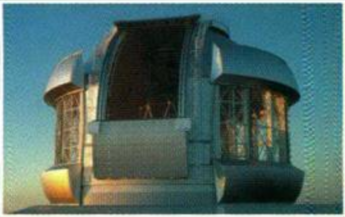

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NAME THE NEBULA

A Stellar Response

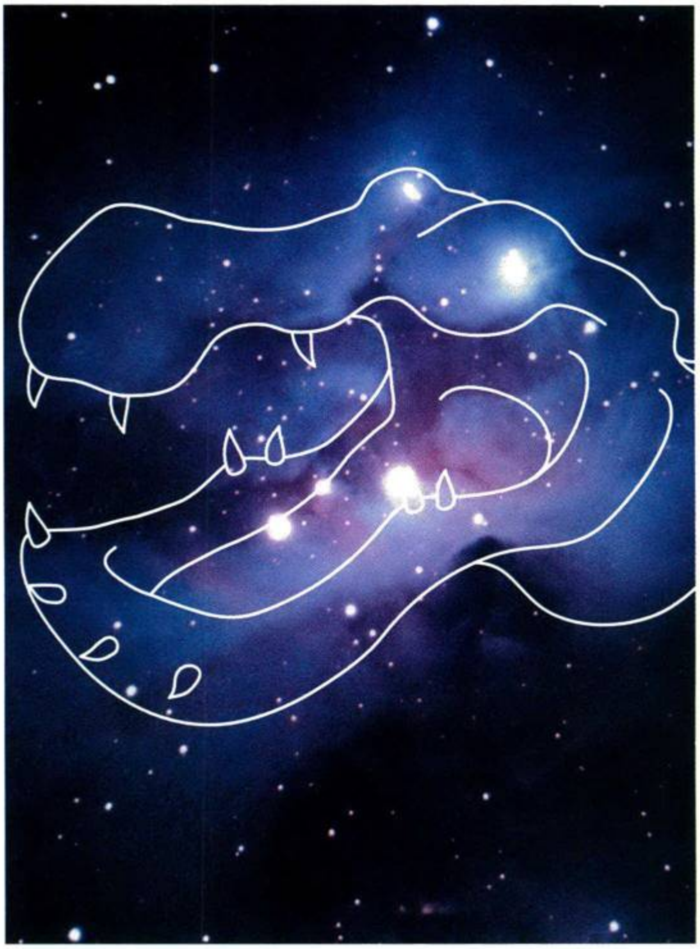
Your response to *Astronomy*'s Name the Nebula contest was awesome. We received thousands of entries from all over the world. Letters came from a diverse group of readers, including moms, dads, children, doctors, college students, and retirees. Many sent artistic sketches and explanations for their entries.

Several participants even made this a family or collaborative classroom project. Special recognition goes to Jason Carter's East Burke Middle School students in Icard, North Carolina, and Ms. Krokee's first-grade class at Twentynine Palms Elementary School in California.

Many letters included humorous and heartwarming comments. Jim Jackson from Fort Worth, Texas, explained his entries by saying, "Some may be a stretch, but it all depends on how you orient the photograph, right?" Barry Jenness told us in an e-mail, "You'll be seeing things all day before you finish this competition."

But Megan Sewards from Spencerville, Indiana, summed it up best by saying, "Anything up there is too beautiful to have a number for a name."

Thank you for sharing your ideas. For us, the hard part was choosing the winners. Read on to discover the winning monikers in this special edition of Hot Shots. As you will see, it is amazing what imaginative observers can see in the dust trails and beautiful imagery that make up our universe. — *Julie Sherwin*



Jason Ware

NGCs 1973, 1975, 1977: Alligator or Crocodile Nebula

CARY WALOWITZ
Hollywood, Florida

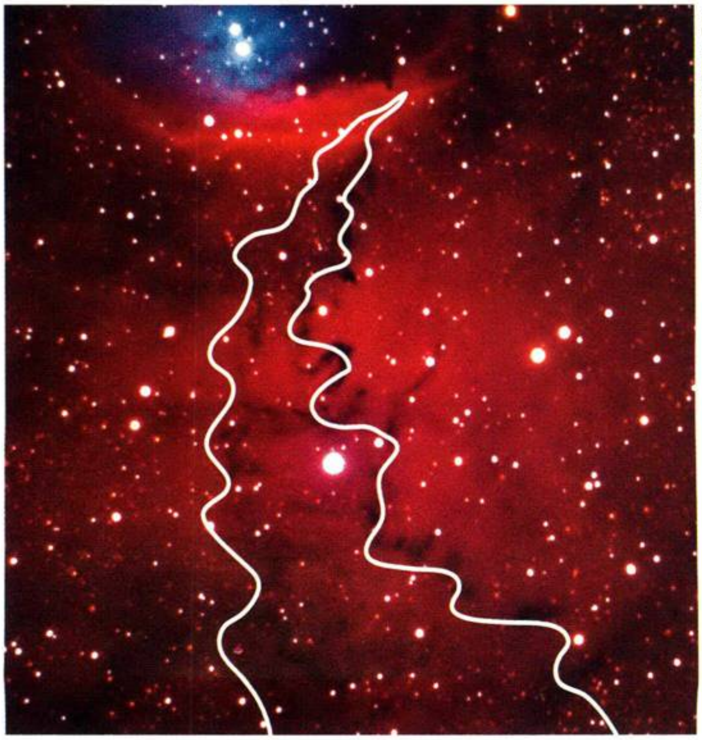
DYLAN EVANS
Marlboro, New Jersey

WESLEY VANCE
Erin, New York

SYDNEY NATALE
Oklahoma City, Oklahoma

PAUL VINTON MCBRIDE
Harrison, Arkansas

TREVOR BYRNE
Big Ridge, Nova Scotia



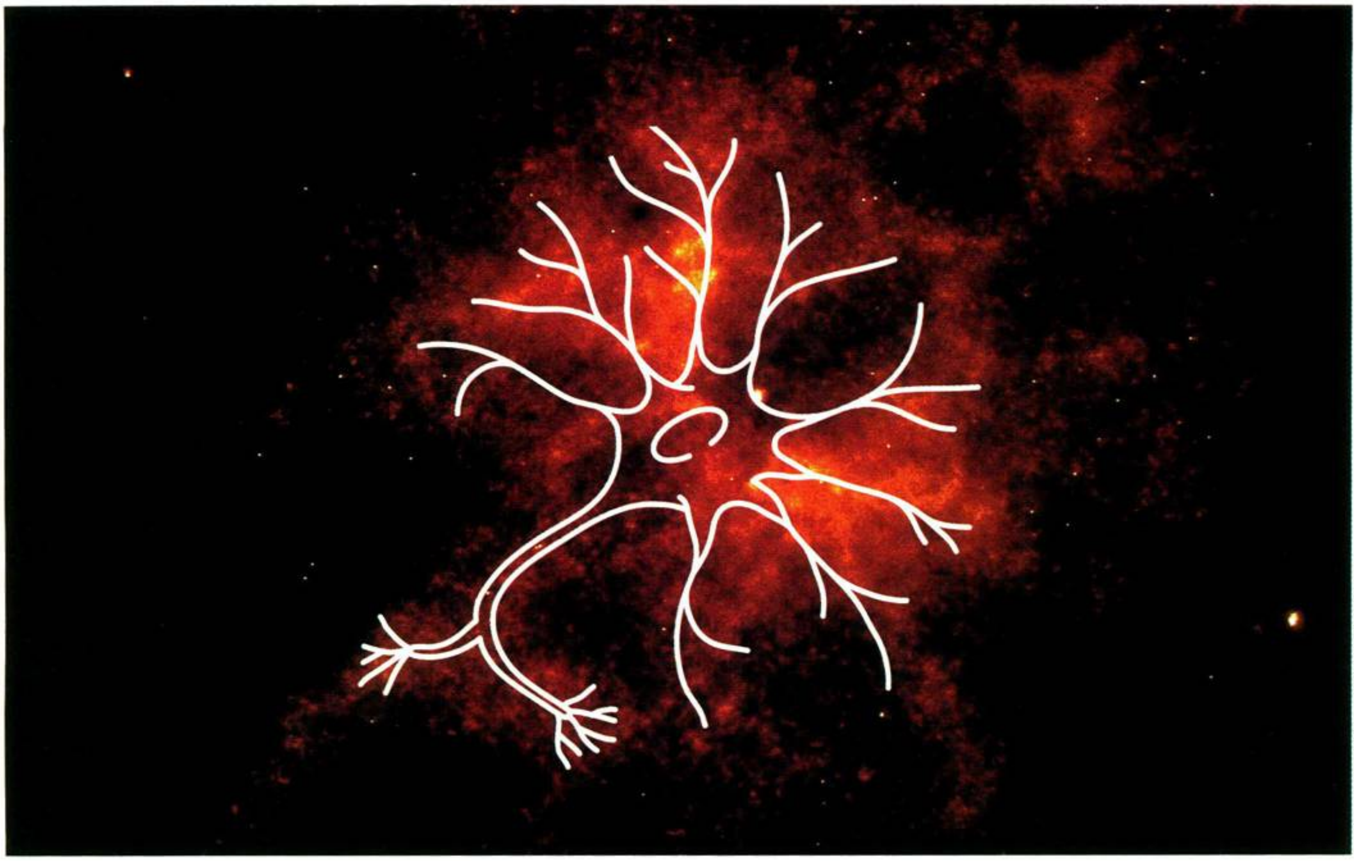
Ken Blankenship and Dennis Batis

NGC 6559: Lazy River Nebula

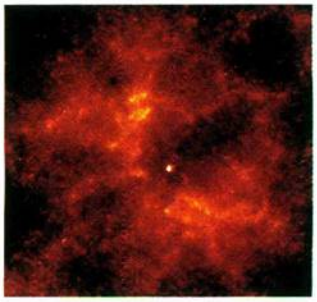
GERRY KELLY
Dixon, Illinois

KEN HOTELLING
Ramona, California

STEVE HAYHURST
Kirkland, Washington



Sally Heap, NASA/Goddard Space Flight Center



NGC 2440: Nerve Cell Nebula

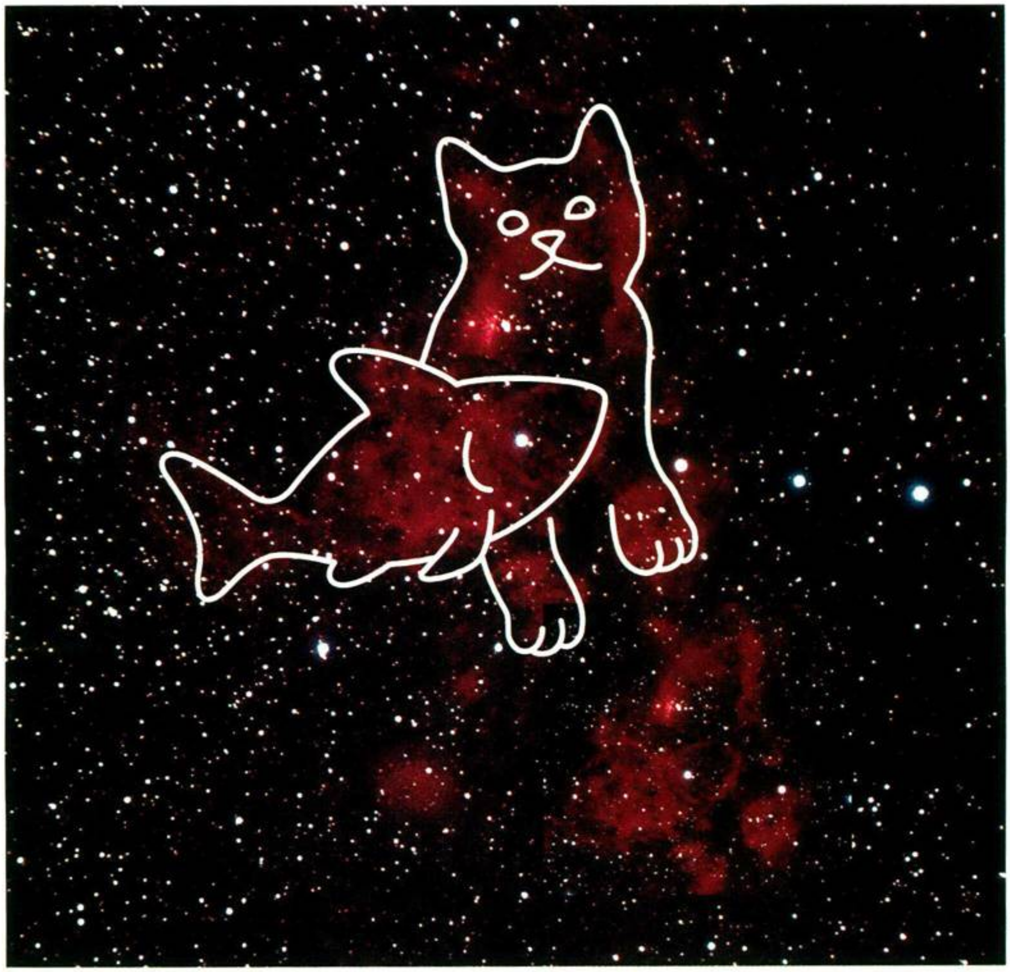
KATHERINE C. DODSON

Martinsville, Virginia

NGC 6357: The Cat and Fish Nebula

ANGELA CAPONE

Preston, Connecticut



Jason Ware

Honorable Mentions

NGC 6559
Loggerhead Turtle, The Bowler, Fluttering Ribbon

IC 1318
The Wisp, Praying Mantis, Ghost Dance

NGC 6357
Canine Nebula (a puppy dog lying down)

IC 1396
Raspberry, Wolf's Head

NGC 281
Waving Flag, Manatee

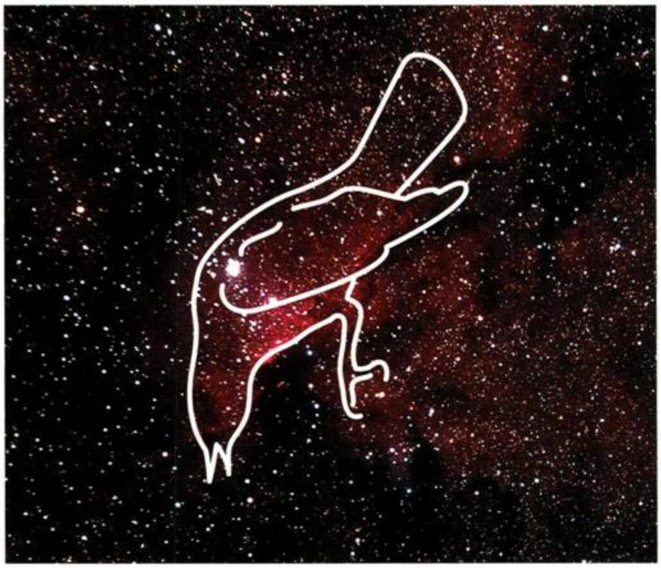
NGC 2440
Fiery Mask, Wedding Ring, Tinkerbell flying through the night

NGCs 1973, 1975, 1977
Rising Phoenix, The Goalie

NGCs 6193, 6188, 6164, 6165
Tiger, Old Dog

IC 2948
Jimmy Durante, Parrot's Head, Laughing Witch, Camel

NGC 7662
Pansy, Chili Pepper, Magical Mirror

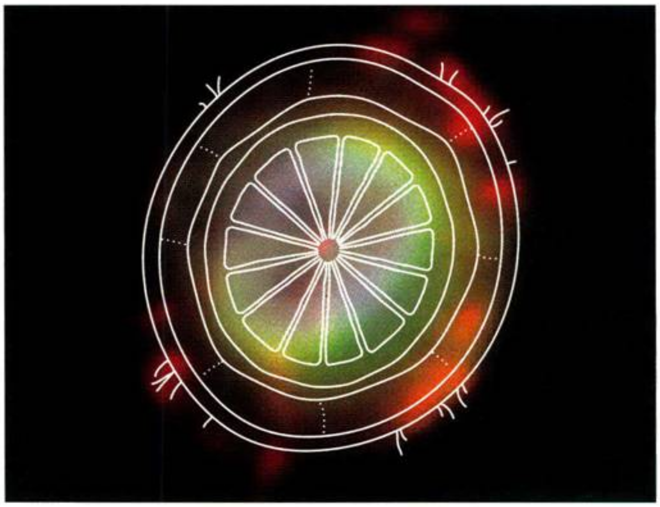


Luke Dodd

NGCs 6193, 6188, 6164, 6165: Blackbird Nebula

CAROL WEBB

Richland, Washington

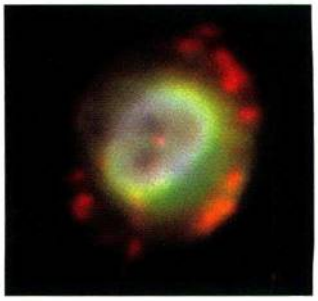


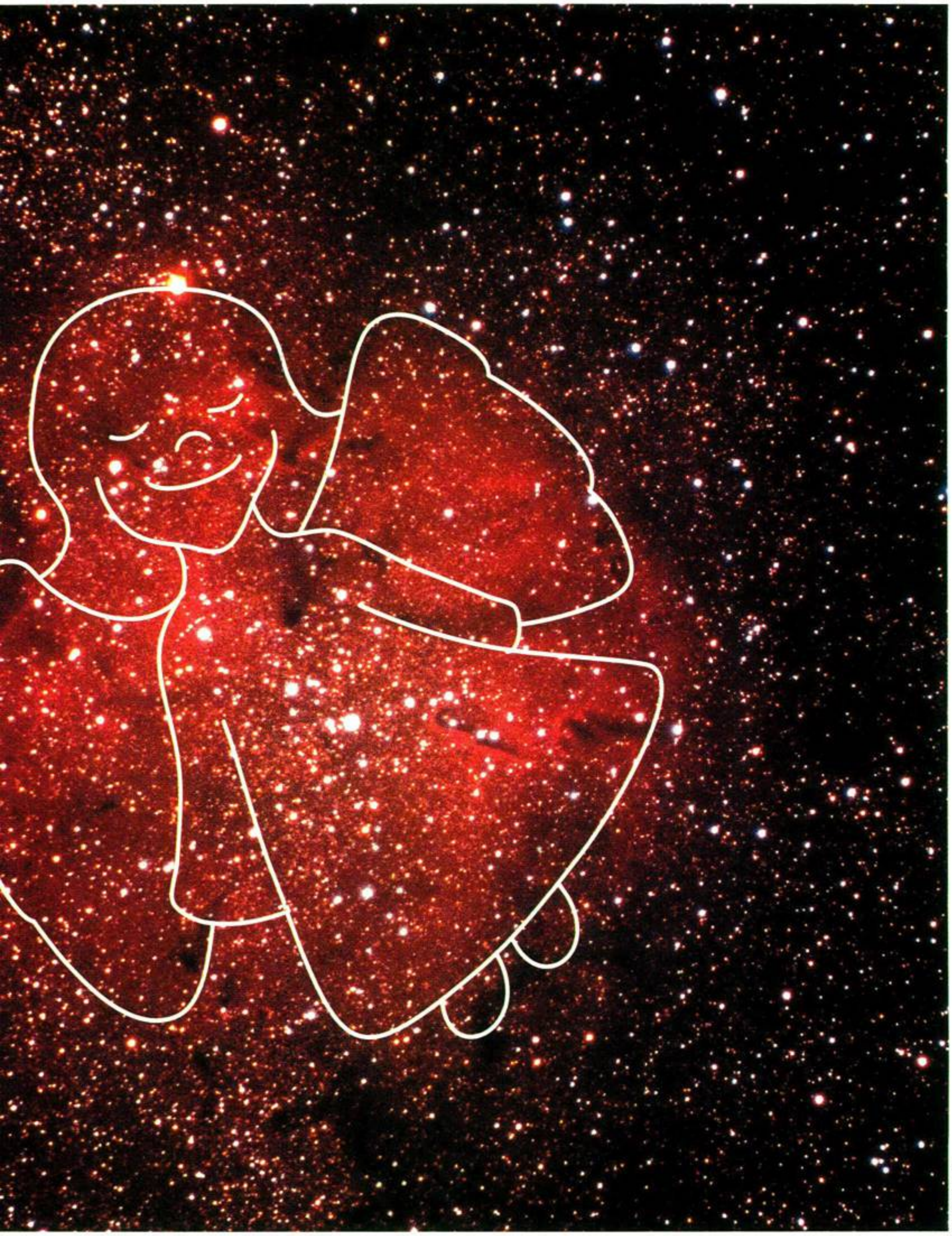
Bruce Balick

NGC 7662: Lime in the Coconut Nebula

MARTHA LOSCH

Palo Alto, California



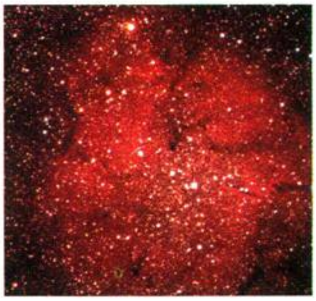


Sauro Donati

IC 1396: Snow-Angel Wings Nebula

ED CLAMPITT

Cherryvale, Kansas



Most Popular Names

NGC 6559
Aladdin's Lamp, DNA, Cracked Crab, Cracked Egg, Turtle

IC 1805
Heart, Valentine, Ram's Head, Bull's Head, Bovine

IC 1318
Sea Horses, Oyster, Pearl

NGC 6357
Lobster, Scorpion, Crustacean

IC 1396
Sand Dollar, Wolf's Head, Strawberry, Popcorn

NGC 281
Leaping Fish, Tornado or Twister, Shrimp, Pac-Man

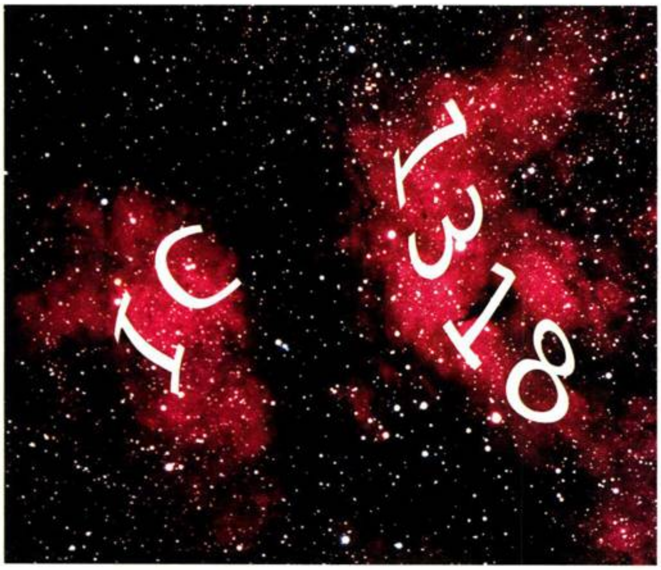
NGC 2440
Rorschach, Ink Blot, Hibiscus, Bug Splat

NGCs 1973, 1975, 1977
T-Rex, Phoenix, Phantom of the Opera, Hawk, Bigfoot

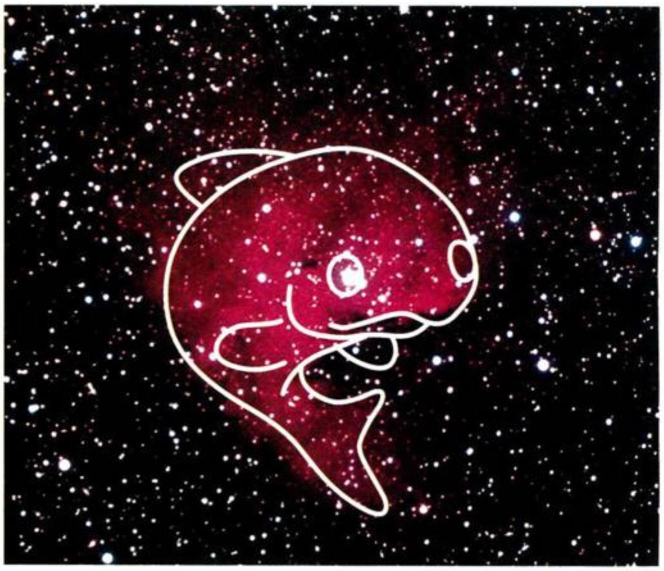
NGCs 6193, 6188, 6164, 6165
Hammerhead, Flying Bat, Vulture's Head, Koala, Chihuahua

IC 2948
Lighthouse, Clown, Rose, Tulip, Poppy

NGC 7662
Kiwi, Lime, Barn Owl, Dragon's Eye, Scarab, Sea Turtle



George Greaney



Jason Ware

IC 1318

JEAN-PAUL KEULEN

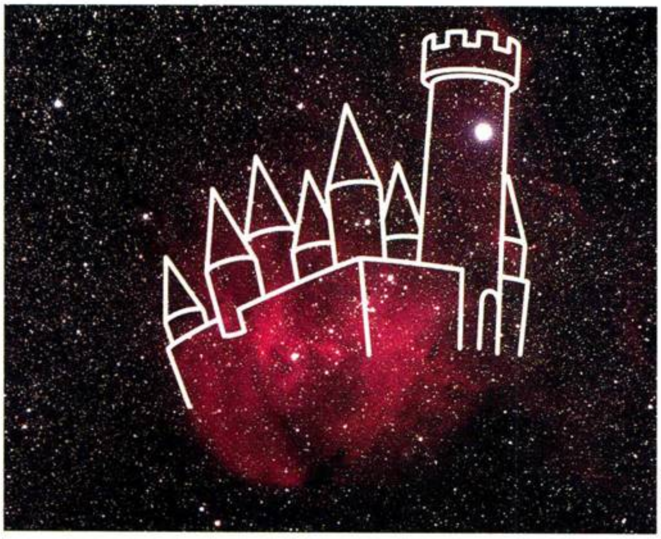
Leiden, The Netherlands

"A mess that doesn't look like anything in particular, so we might just as well keep calling it IC 1318."

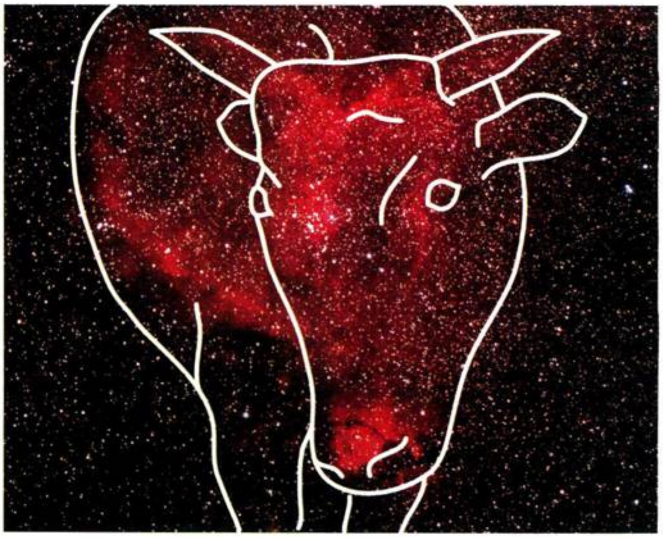
NGC 281: Leaping Salmon Nebula

JOHN WEST

Novar Gardens, SA, Australia



Luke Dodd



Steve Mandel

IC 2948: Mystic Castle or Sky Castle Nebula

Mystic Castle

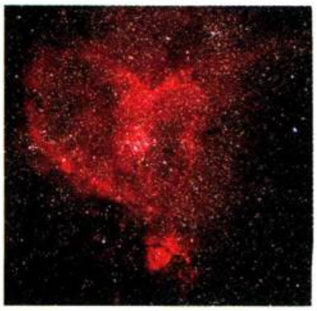
KAYLA MILLER

Icard, North Carolina

Sky Castle

RICH CERMAK

State College, Pennsylvania



IC 1805: The Steer

MICHAEL FALDUTO

Pequannock, New Jersey

DAVID LAKE

Silverdale, Washington

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